THE NAVIGATOR

AFP 50-3 Volume XXII, Number 1 Winter 1975

NAV OF NOTE

Colonel John M. Kirk is Vice Commander of the 323d Flying Training Wing which operates all of the Air Force's navigator schools at Mather AFB, California.

A native of Florida, Col Kirk was graduated from the United States Naval Academy in 1950. His first active duty assignment was as a military training officer, a position he held for six months until he entered navigation school in December of 1950. Upon completion of basic navigator training at Ellington AFB, Texas, he was assigned to Mather AFB for bombardier training and was graduated in January 1952.

Col Kirk's first operational assignment took him to the 326th Bombardment Squadron at Fairchild AFB, Washington, and the Strategic Air Command's B-36. He spent four years as a lead and select crew navigator and amassed over 2000 hours in this capacity. When the 326th converted to the B-52, he was upgraded to the radar navigator position and accrued another 2000 flying hours in five more years. His final assignment in SAC took him to the 4141st Strategic Wing at Glasgow AFB, Montana, where he was the wing Senior Standardization Crew Radar Navigator in 1961 and 1962. Col Kirk had the rare experience of having spent over ten years in SAC with the same combat crew.

In 1962 and 1963, Col Kirk attended the University of Arizona for a one year AFIT graduate program in astronomy. After completing this program, he was assigned to the Air Force Academy where from 1963 to 1966 he served as an instructor navigator, course director of astronomy and director of the Academy Planetarium. While at the Academy, he also earned a master's degree at the University of Denver.

Col Kirk was assigned to the Air War College, Maxwell AFB, Alabama, in July 1966 and was a distinguished graduate of the class of 1967. He also received a master's degree in International Relations from George Washington University while at the AWC. His subsequent assignment took him to the EB-66 and after a training stop at Shaw AFB, SC, he reported to Takhli RTAFB, Thailand, in December of 1967. For the first half of his tour, he served as the Chief of Standardization and Tactics and participated in 109 combat missions, 24 of those over North Vietnam. Promoted to colonel while at Takhli, he completed his final six months by serving as the Deputy Base Commander.

After returning to the states in late 1968, he attended the Defense Intelligence School and the Chinese Language School in Washington, DC. In June of 1970, he was assigned to the American Consulate General in Hong Kong and for three years served as the senior Air Force officer with the Defense Attache Office. His last assignment before coming to Mather was as Vice Commander of the USAF Officer Training School at Lackland AFB, Texas. He was assigned to his present position in July of 1974.

Col Kirk's military decorations include the Distinguished Flying Cross, Bronze Star, Meritorious Service Medal, Air Medal with seven Oak Leaf Clusters, and the Air Force Commendation Medal with two Oak Leaf Clusters.

FROM THE EDITOR

An old cliche that has been around since day one is "No news is good news." That is probably a true and welcome thought when you refer to bills, tax notices, unwanted PCS orders, or the like, but it is not at all true when you are in the magazine business. In order for us, the publishers, to know how we are coming across to you, the readers, we must have some feedback. We are not looking for pats on the back; honest, critical evaluations would be much more beneficial in helping us provide you with what you want as readers. If you feel that THE NAVIGATOR is too technical or not technical enough, too diverse or not diverse enough, too informal or not informal enough, let us know. We'll never know how you feel unless you take the time to write to us and express your feelings as to the quality of *your* magazine. Again, it is the goal of our staff to make THE NAVIGATOR the best recurring periodical in the Air Force, but that is an impossible task without the help of you people in the field. So let us hear from you all real soon, okay?

Editor, THE NAVIGATOR

TO THE EDITOR

Dear Editor:

I very much enjoyed your fall issue and read it from cover to cover. All of the articles were extremely well done and the authors are to be congratulated for their creativity and initiative. One thing I particularly liked was the ratio of technical articles to other types with the technical being on the low side. Do you plan on keeping this ratio or are you going to flood us with a bunch of technical jargon that very few people will ever take the time to wade through?

Major Kurt Wimsett
452 Flying Training Squadron
Mather AFB, California

As you are probably aware, the purpose of THE NAVIGATOR magazine is to present articles of technical and professional interest to the Air Force navigator. According to the survey conducted earlier this year, the great majority of practicing Air Force navigators feel exactly as you do. The people who responded to the survey overwhelmingly favored articles of professional and human interest over the technical type. The favorite of most seemed to be in the area of navigator career planning and development. It is our goal here at THE NAVIGATOR to satisfy the majority so we definitely do plan to stay with the ratio you saw in the fall issue. That is not to say, however, that we have an aversion to technical articles because we don't. THE NAVIGATOR will definitely continue to print all technical articles that are of interest to a major segment of our navigator force. So please keep the articles coming—all kinds of them.

Ed.

Dear Editor:

I wrote this poem some time ago. Only yesterday I noted in a recent issue of the AIR UNIVERSITY REVIEW that navigators are still treated with less than the respect due.

I feel qualified to publish such a poem.

1. I was commissioned a navigator at age 20. 75% of my class washed out, and I washed back two classes.

2. I was 4th in a graduating class of 38 in pilot training. Only 28% of my class washed out.

3. I was double rated, and selected to tour ADC bases lecturing on ECM.

4. I was officially classified among the top 5% of all Air Force fighter pilots at age 25.

Pilots and navigators have different jobs in the air. A pilot exercises a skill, the navigator practices a blend of art and science.

Both should do the same jobs on the ground. Given a chance, my personal belief is that navigators will do better at more of those ground jobs than do their pilot peers. My experience has been, almost universally, that navigators are more aware of the world, more involved in the realities and enormities of life.

STAND TALL

The wings and crest above your pocket mark you an extraordinary man.

You are a scientist.

Temperature, dew point,
Airspeed, heading,
Pressure, altitude,
Last known position, time and drift—
These are the variables in your equation.

Electronic devices, plotters,
Flight Instruments, charts,
Chronometers, calculators,
Books of tables, sextants and dividers—
These are the tools in your laboratory.

Deductive reasoning, grid,
Pressure pattern, Loran,
Celestial, consolan,
Distance measuring equipment, radio and radar—
These are the methods of your inquiry.

You are an artist.

You weave away mystery
And clothe yourself with the pure garment of logic.

You chip away formlessness
Leaving for yourself the sculptured moment of truth.

You paint away the unknown
With broad strokes on the canvas of certainty.

You are the intellect of every crew with which you serve.

You are the navigator.

Dallas L. Blevins
2328 Skyland Drive
Tallahassee, Florida

Thank you very much for your letter and extremely well done piece of prose. It is not very often that we navigators receive such kudos, especially from fighter pilots. Naturally, I agree with what you say and I'm sure our readers do, too.

Ed.

THE NAVIGATOR

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Contributing photographers for this issue are MSgt David W. Menard and SSgt William H. Nelson.

This issue's cover depicts the most recent innovation in navigator training. The two-seat T-37 and the multi-place T-43 represent the all-jet fleet that is currently in use at Mather's 323d Flying Training Wing.

today's navigator trainee — A NEW BREED

Colonel Robert O. McCARTAN
Deputy Commander for Navigator Training
323d Flying Training Wing
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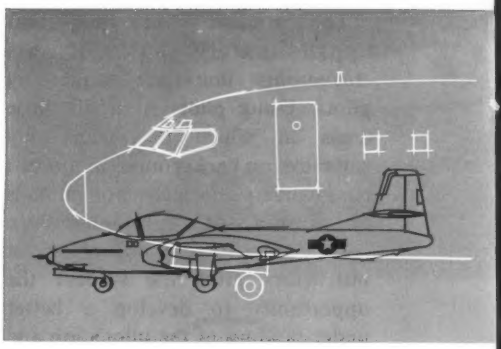


Mather AFB, California. This is the home of Navigator Bombardier Training (NBT), Electronic Warfare Officer Training (EWOT), and a brand new program called Undergraduate Navigator Training (UNT). Yes, you read correctly—there is a brand new program here called UNT. The name may be the same as it was when you were here, but the face and complexion of navigator training have changed to the point where they are hardly recognizable to anybody but the more recent arrivals at Mather. The old T-29 program ended in October 1974 and a new era in navigator training has begun!

Can you even begin to imagine pilots being used as instructors for student navigator training flights? And in a T-37 jet trainer at that? Well, that's exactly what's happening this month when class 76-03 enters the new program. This new UNT is a comprehensive program that affects the entire spectrum of navigator training and encompasses a whole new stable of training vehicles as well as a new philosophy. And the most visible and unique change from the old program is the use of the two-seat T-37 jet trainer as the starting point for the training of the Air Force's new navigator students. The ageing T-29's, after long years of safe and faithful service, are departing the Mather scene.

The new UNT program, by using a combination of T-37 and T-43 jet aircraft, will give the aspiring young navigator an opportunity to train in aircraft and systems that will closely parallel those in the operational Air Force. This all-jet program updates the training of students and better prepares them for the high performance aircraft that the majority of graduates are assigned to. It provides the Air Force with Navigators/ Weapons Systems Officers who are better qualified for the increasingly sophisticated weapon systems of today and the foreseeable future. His training will also enable him to progress into his operational aircraft much more quickly than ever before. For the first time in the history of navigator training, the new graduate will have experienced the environment of both small and large jet aircraft.

For years we have inadvertently done our student navigators a disservice. We have never before been able to provide proper training in the areas of voice communications and mental dead reckoning. These two weak areas have always surfaced immediately when the new navigator reported to his first operational assignment. But now a block of instruction called *Airmanship,* presented early in the program, should correct these deficiencies and concurrently produce a navigator who can be an aggressive, take-charge crewmember. *Airmanship* includes training in areas of flying that are not directly related to navigation but do help make the student a well rounded, more knowledgeable asset to a crew. It also provides an overview of his future role as a navigator, the big picture so to speak, that past graduates have not been exposed to. Overall, *Airmanship* training includes emphasis on flight safety, aerodynamics of flight, time and course control, mental dead reckoning, use of AFTO 781, departure and arrival procedures, T-37 systems, T-37 flight planning, and navigation and communications radio procedures.

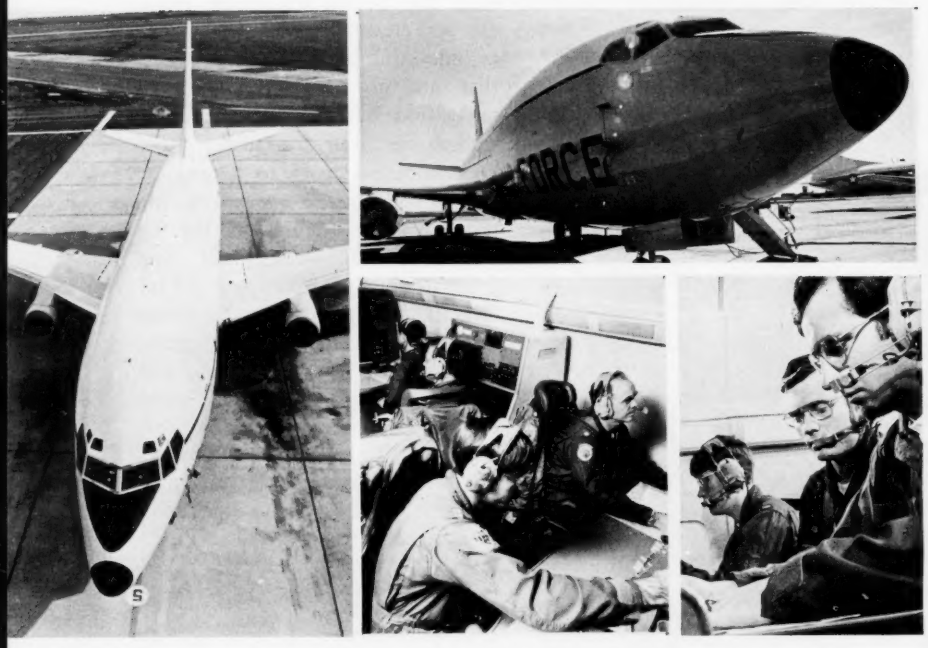
The student will find that approximately half of his *Airmanship* units are taught by pilots. Using pilots to teach those areas in which they can fully capitalize on backgrounds as aircraft commanders and instructor pilots is an important innovation in navigator training. Exposure to pilot instructors gives the student the opportunity to develop a better understanding of the pilot's job and helps build a rapport with the other half of the rated force prior to joining an aircrew. The emphasis has switched from the parochialism of an all navigator instructor force to a joint cooperative effort directed toward turning out a well-trained crewmember with a specialization as a navigator. In the environment of many of today's aircraft, there is no sharp delineation between crew duties and it is necessary for each crewmember to be well-versed in the duties of the other.

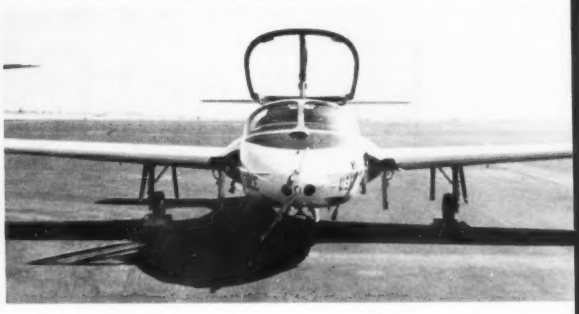
The UNT program is a total package that consists of the T-37 and T-43 aircraft, the new T-45 ground simulator, and the T-40 instrument trainer. The combination of these training vehicles will provide the student with more exposure to current Air Force weapons systems than any navigator training program in the past. We now have an all-jet fleet of 25 T-37s and 19 T-43s on which the student will receive 26 flight missions, five in the T-37 and 21 in the T-43. He will log approximately seven hours in the T-37 and 105 hours in the T-43 for a total of 112 student flying hours. This is quite a reduction of flying hours and an enormous savings of dollars when compared to the 243 T-29 flying hours of just three short years ago.

Each student will fly a total of five missions in the T-37, four at the very beginning of the program and the fifth about halfway through. Starting with his first T-37 mission with his pilot instructor, the student will participate in all phases of flight from flight planning to post-flight inspection and the completion of aircraft forms. In the air, he will be required to monitor and direct the aircraft on arrivals and departures and during cruise he will direct the aircraft using radio aids, map reading and mental DR. He will also be expected to make all required radio calls to the controlling agencies, a duty that has been overlooked in previous navigator training programs. In the T-37 phase of training, the student will not even see a pair of dividers, plotter or log, but he will see the "big picture" of his future crewmember duties long before he becomes involved in the technicalities of navigation. Early in the program, he will gain a deep understanding of where he is headed.

The introduction of the T-37 into UNT impacts on training in many ways. Hopefully, these early flight missions will foster excellent morale and esprit and motivate the student toward flying in general and UNT in particular. Many students have adopted a certain image of the Air Force by the time they arrive at Mather, and by letting each student experience as many different phases of flying as possible, we hope to do much toward meeting that image.

Upon completing the *Airmanship* phase and the first four T-37 rides, the student will enter the T-43 phase where he will transition to the use of manual dead reckoning and the basic tools of his trade. Once these are mastered, he will use abbreviated log procedures compatible with the sophisticated avionics aboard the T-43. This is not to say that the student will be less qualified in the use of manual navigation procedures, but it does allow us to teach flexibility. Many of the flight and simulator missions call for the selective, instantaneous failure of various avionics components. The student is required to revert from automatic to manual DR procedures with the flip of a switch. We consider this a tremendous capability because it requires the student to use his equipment to its maximum capability when it is working. He must also learn to evaluate it so as to recognize when he does have a system failure and then work around it when necessary. The student will still use celestial, radar, and radio to navigate, just as he did in the past, but now he will have to integrate numerous other systems that will initially serve to complicate, rather than simplify, his task. In short, the emphasis is on the mental and manual functions of navigation as





well as deciding which system is the best and most reliable for the task at hand. These points, we feel at Mather, are the gut issues in our new program and we plan to place a great amount of emphasis on them.

The T-43 phase is fast-paced. The student is first exposed to most of the avionics equipment and learns to use it in conjunction with radar and radio fixing. He is then tasked to use all the equipment on board in order to see the relationship of one aid to another. His equipment includes VOR, TACAN, an inertial navigation system, an AWADS-type radar, and a navigation computer system with INS, Doppler, and radar interfaces. Experience in the T-43 program so far has shown that the student adapts readily to this complex array of avionics gear. Again, our concern is always that he does not become locked into and dependent upon any one system.

Once the student has gained experience in equipment basics, he progresses to the more traditional emphasis areas. Two low level radar missions followed by three day celestial, three night celestial, four global (overwater), two grid, two advanced tactical low level, and a final command-oriented mission. Each phase is initially taught in the classroom, reinforced in the T-45 simulator, and culminated in the T-43 aircraft. The basics of mental and manual DR are constantly reemphasized throughout the academics and simulator / flight missions.

The student flies his fifth T-37 mission when he is approximately halfway through the program. The purpose of this mission is to complement the training he has received to date. The supporting academics prior to this flight are perhaps a little hard to believe for many old head navigators. The students receive a block of instruction called *Advanced Airmanship* which is taught primarily by pilots. Here he reexamines aerodynamics of flight, and receives advanced training in instrument departures and approaches. He won't get away with just talking about instrument procedures; he has to shoot a few departures and approaches with an IP in the T-40 ground instrument trainer which has a cockpit layout similar to the T-39 Sabreliner. The goal is not to make the student an instrument pilot, but rather to develop a better understanding for the pilot's job as well as increase his knowledge of instrument procedures by providing him six hours of "hands-on" flying in the T-40. We feel that a student who has attempted to "fly" an instrument approach and departure in the simulator, under IMC conditions, is a more aware and valuable crewmember. The fifth T-37 flight mission will also include a demonstration of some unusual attitudes for the first time. He will be able to see and feel what it's like to be on his back and experience a few Gs in a pull up maneuver.

It should be evident that pilots will be a key to the success of the program. They are not a detached, disinterested auxiliary branch. Rather, they are being absorbed within the navigation training complex as full-fledged partners in the training process. For example, they will have primary responsibility for the monitoring of the T-37 flying and *Advanced Airmanship* phases of instruction. Altogether, 55 ATC experienced, T-37 IPs, drawn from UPT bases around the country, will form the cadre that will handle the flying, simulator and academic training during the T-37 phase of training. They have already displayed an outstanding spirit of enthusiasm for the basic concepts of the program, and this excellent attitude will undoubtedly reflect on the quality of our future navigator product.

Perhaps UNT's greatest impact will be on the student's view of his role as a navigator. The increasing use of pilot-WSO teams and advanced avionics equipment have made the navigator's job less easy to define. New requirements for more demanding skills must be fulfilled. This new, all-jet UNT program is designed to be a modern and flexible package that will make the student better able to meet those requirements by preparing him to be a well-trained navigator and well-rounded crewmember. We hope you'll like him.

Reflections On Refraction

Major Nolan R. KELLY
911th Air Refueling Squadron
Seymour Johnson AFB, North Carolina

How many of you have ever had the experience where you were given instruction by one of your squadron instructors and ended up more confused than you were before he started? Have you ever felt, after an academic block or flight mission, that your instructor was talking to some PhD rather than a new guy trying to learn the basics of navigation? I'm sure that all of us have had some bad experiences insofar as instruction in navigation is concerned and, what really smarts, is the fact that it doesn't have to be that way at all. Consider the following treatise on refraction, something that all of us as navigators have got to be concerned with.

"Light, or other radiant energy, is assumed to travel in a straight line at uniform speed, if the medium in which it is traveling has uniform properties. But if light enters a medium of different properties, particularly if the density is different, the speed of light changes somewhat. If light traveling from a great distance enters a more dense medium, such as the passage from air into water, the speed decreases. Should the light enter the more dense medium at an oblique angle, this change in speed causes a change in the direction of travel. This change in direction of motion is called refraction. In sighting a celestial body, the effect of refraction is to make the body appear higher in the sky than it actually is. The atmospheric medium contains many irregularities which are erratic in their influence upon refraction. Air temperature and atmospheric pressure are known to progress linearly and corrections for these two errors can be evaluated, tabulated, and applied. Humidity has a relatively slight effect on refraction. Latitude has a slight effect upon refraction because of the decrease in the radius of the earth and the increase of gravity as latitude increases. Dispersion of light of various colors results in light from blue stars being refracted more than light from red stars. As a correction to sextant altitudes, refraction is negative because it causes the measured altitude to be too great. It decreases with increased altitude of the sextant, and applies to all celestial bodies, regardless of sextant or horizon used."

The foregoing paragraph, extracted from "AMERICAN PRACTICAL NAVIGATOR" (H.O. 9) by Nathaniel Bowditch, is obviously not a profound, theoretical or complete study of refraction. But it is very clear, concise, well-written and says exactly what Bowditch wanted it to say. Nathaniel Bowditch made a vow to put nothing in his book that he could not teach to every member of his crew. He fully intended to keep his work within the understanding level of the *average seaman* and obviously did just that. I selected this excerpt from Bowditch as an example of how far an instructor should be prepared to delve into a subject depending upon the student's capacity for understanding. I think you can imagine how confusing and complex an explanation of refraction could be if you got carried away and ignored the background of the reader or listener. I also chose the subject of refraction as an illustration because refraction can be made analogous to instruction in the following way. *If light is equated to navigational knowledge, and the medium to an instructor, then the analogy is complete.* What this article is really asking, then, is what do you as an instructor or potential instructor, do to this navigational knowledge (light) as it passes through you (the medium) to the student? Do you refract it at the proper angle or do you distort it beyond recognition?

Perhaps I should explain right now why I have taken a great interest in this subject of instruction. After 14 years as an ECM operator, I was grounded for medical reasons, but later informed that I could continue on flying status as a navigator. Having been an instructor EWO and having instructed in other fields as well, I was naturally interested in instruction and more observant and critical of the navigational instruction that I received on my return to the field. Since I have been back and forth across the Pacific a few times now without incident (crossed fingers still), I can look back upon this instruction with a higher degree of objectivity. The attitudes and techniques that I was exposed to were generally excellent and probably much like those you experienced. But there were always those guys on the other side of the fence,

the guys with the black hats and harsh voices, and even though they were the exception rather than the rule, they're the ones who provide the excellent examples of how not to do it.

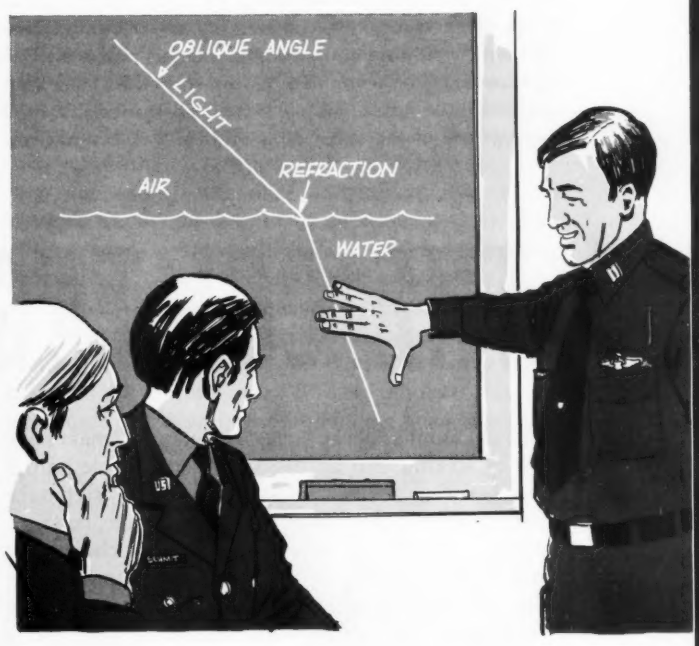
In many of my learning situations, communication seemed to be from the instructor to the student with no reverse flow. The instructor seemed offended if the student asked a question. All instruction manuals on teaching emphasize that in order for communication to take place, there must be a transmitter, a receiver and a symbol. But even if all of these criteria are met, it still doesn't mean that *effective* communication is taking place because now another parameter called feedback enters the picture. Part of an instructor's duty is to detect and identify weaknesses in the student and then design a reply or program that will begin to correct those weaknesses. This cannot possibly be achieved without two-way communication. In the book, *Principles of Management,* George R. Terry says that "All communication is two way. When communication moves freely in both directions, greater exchange of ideas and concepts are won and the way is open for greater understanding."

There are some common expressions used by instructors that normally are favorable to two-way communication. But when they are used without sincerity, as crutches, fillers or excuses, they often lead the user into complacency, apathy and in some cases, contempt. When this occurs, these expressions can become real barriers to communication. For example, how many times have you heard an instructor say, "You know what I mean?" And you felt that what he was really saying was "You wouldn't dare ask me a question after I have done such a brilliant job of explaining this so shut up and let me get on to the next subject." Real effective communication, right?

How many times have you heard this one? "You've all heard this briefing before so I won't bore you with details. I'll just hit the high points." This type of instructor is one of the most blatant, self-fulfilling prophets who tends to turn you off before you even get started. After being exposed to this situation one too many times, I finally realized that I had to stand up at this point and say, "No, I have *not* heard this briefing before and will you please go over the entire thing very carefully?" Even then, it was difficult to get this type to explain anything because he was convinced that I had no need for *all* that information, even though he thought enough of it to put it in his original briefing. Maybe he was just in a hurry and would rather have been someplace else at that time.

Then there's the guy who very candidly lets you know that "Anybody who has been in the Air Force, wears wings, or has a star on his wings should know THAT." Have you ever felt so stupid before, knowing that you should know THAT information, according to your instructor, and you really have no idea what THAT is all about? It is really hard to realize that such a loaded generalization could be spoken by an instructor in this modern Air Force. Be very careful in the use of this type of generalization because your students will find this to be the most contemptible type of attitude on your part. It will surely go the furthest toward convincing them that you have absolutely no interest in their well-beings.

The one expression that I guess I've heard more than any other is that old beauty "Any questions?" This old standby was originally intended to be delivered in a manner which would indicate that the speaker would gladly entertain any questions in order to insure that his meaning was clear and understood. But it has somehow been slipped into the tail end of a lecture or lesson and the student has come to accept it as meaning "Don't bother me, I'm in a hurry." When an instructor asks a class or individual student, , "Any questions?", he should do it at a time when there is enough time to answer questions. Otherwise, it invariably will be interpreted as a cue for closing books and high-tailing it out of there.



One of the real dangers of instructing is the failure of the instructor to recognize that the student and he do not share a common core of experience. Since the role of a navigator covers such a broad spectrum of activities, every instructor must understand that each subdivision of the field of navigation has its own expertise and terminology that is unlike any other. Since I was transferred from one branch of the art into another, I have had ample opportunity to observe the difference in terminology and can see what this lack of a common core of experience can do to the learning process. I am familiar with Fourier Analysis, Butterworth Filters, and Element of Expense Investment Codes because I have had some experience with them. But what did those terms mean to you as you read them? I deliberately threw those terms at you so you can realize how meaningless a word or concept is when you hear it for the first time. If you use a word or two that the student does not understand, and he does not question it, then you can be certain you've blown that explanation and the student must learn the concept by hard experience.

To prove to yourself how important word selection is in instruction, try this little experiment the next time you teach a class or fly with a student. Think of a tree and fix the vision of this tree in your mind. Then ask your student or a number of students to think of a tree and describe it to you. Chances are that if the student describing the tree was raised in the same area as you, he will describe the exact tree you have in your mind. Each student will invariably describe the tree that was most commonly found near his home and, in most cases, even when two people from the same area describe their trees, they will still vary greatly in their descriptions of the same type of tree. S. I. Hayakawa, the renowned semanticist, said, "The meanings of words are not in the words, they are in us." Every student's experience is different from every other's and you as an instructor must realize how important this difference can be when presenting your instruction.

There are dozens upon dozens of teaching techniques that we should know as instructors, but unfortunately we do not all have the opportunity to attend instructor training schools that would present us with all the subtleties of instruction. There are, however, many resources available to us and we must take advantage of these resources if we are to do the best jobs that we can for our students. The real authority on teaching is AFM 50-62, *Principles and Techniques of Instruction*. All people responsible for any type of instruction should be thoroughly familiar with this publication. Another good resource is SACM 60-7, a publication prepared by educational authorities for instructor pilots but easily adapted to navigational instruction. Hopefully, there will be enough dollars available for all instructors to eventually attend a Central Flight Instructor's Course, but with the austerity program in full swing and the money crunch getting tighter all the time, this is very doubtful. Therefore, the responsibility for improving our techniques and honing our abilities rests solely with us. You can become any one of the types that I have previously discussed or you can become the type that students always want to fly with or listen to. You can be a Nathaniel Bowditch and refract the light at the proper angle, or you can distort that same light to the point where the student can't tell the forest from the trees. It's all up to you.

"THE CONTAGION"

Major Kenneth A. KRAMER
7th Bomb Wing
Carswell AFB, Texas

The old familiar cliche "relax and enjoy it" makes one think of sinking into an oversized comfortable lounge chair, listening to soft, melancholy music, sipping a favorite wine or other palate-pleasing beverage, and then topping it all off with a savory, succulent choice filet mignon. The good life we call it. But unfortunately, this cliche has also too often become a way of life in our occupational and professional fields. It's perfectly normal for one to desire comfort, to seek the easy way out, to try to gain relaxation by doing only that which is necessary. The most notorious proponent of this philosophy is the eminent sandbagger that we all know so well. Others, unfortunately, are mere unconscious products of this insidious *contagion,* and press on in their lives without fully realizing its pervasion upon professionalism.

What do I mean when I say contagion? A contagion is the direct or indirect spreading of a disease or evil. It is a bad influence that tends to spread. It is an adoption of the "relax and enjoy it" attitude with respect to an

occupation or profession. Being an advocate of this very attitude during my younger, naive years, my intent in writing this article is not to disparage those who seek its obvious comfort, but to help develop an acute awareness of this subversive devil called contagion. But in order to accomplish this objective, I must reopen a few old wounds and let the blood of my regretful years flow forth.

My initial flight as a numbered crew crewmember was definitely not a happy or auspicious occasion. I distinguished myself as the crew's first navigator to blow it *all* in just one mission. The crew first exceeded the low level corridor limits mainly because I failed to use all available navigation aids. I plotted the present position counters readout as my fix and did not check my DR position or use my radar. Naturally, the counters were in error but I responded blindly—I took the computers for granted because it was the easy way out. Secondly, the radar navigator chose to position his crosshairs on the wrong aiming point due to the mis-setting of the target coordinates. He did not crosscheck my setting of the counters and I did not monitor his crosshair aiming. In other words, we took each other for granted. Then the crew was awarded an unreliable celestial navigation leg due to my erroneous plotting of LOPs and DR positions. Yes, I even took myself for granted.

The lesson exemplified by my embarrassment during that first flight was significantly lacking in impact. But it did make a believer out of me in one sense. I was ensnarled by the popular belief that the necessity for reliability was paramount. So I arduously studied the bombing/navigational computers and Radar Bomb Site plotting methods, and then cleverly developed shortcuts and other innovative techniques to insure reliability. It worked! In time I became the most reliable radar navigator in the wing. However, as my shortcuts continued to lower my circular error average, I became less and less aware of the other equally important crew responsibilities. Complacency began to flourish while proficiency began to decay. Little did I know, then, that professionalism could have produced even better results insofar as my CEA was concerned. But the "contagion" had already taken a tight clutch upon my need for comfort. I was hooked on finding the easy way to do everything.

The planning of a mission and the techniques employed to insure sound and reliable navigation/bombing are prime targets of this covert menace called contagion. Though this disease is quite adept in concealing itself amidst time saving innovations and computerized machinery, one may still detect its syndrome through conscientious introspection. It is usually characterized by one or any combination of the following symptoms: complacency, pomposity, loss of motivation, decline in self-satisfaction, and a grievous

attitude. One catalyst which usually prevails in the creation and furtherance of this contagion is the act of taking things for granted—your equipment, your crew and ultimately yourself. But then, why not? It takes little mental energy and is a very comfortable approach to almost everything. It usually begins as a result of inexperience, lack of confidence, or obvious lack of functional training—definitely not a lack of talents or abilities. This is now where I hope to enter the picture and capitalize on the years that I spent in the clutches of the contagion. I have now made it a personal challenge to help others be comfortable in their jobs, but through *pride* rather than relaxation or the process of taking the easy way out. I was once a direct product of the contagion and now I want to be its greatest enemy.

When I assumed my duties as an instructor at Castle, I immediately realized that a change must occur in my professional behavior. I concluded that teaching ability had to be dependent upon motivation, professionalism and a sincere belief in your work. Not only was I obligated to impart the correct requirements and techniques of navigation and bombing, but I also had to teach the confirming reasons, both by logic and example. I had to teach students to be effective and comfortable in their work—not merely to relate to evaluation standards set upon them but once a year. In addition, each student's talents and confidence in his own abilities had to be realized by himself. He had to learn to affix priorities to his equally important responsibilities of planning, navigation, coordination, and checklist usage. But how was I to accomplish all of these things? Especially when I was just beginning to

come out of the contagion syndrome? And then it hit me! Simply by being professional in my approach, professional in my job, learning everything I could about my job, and having an unwavering belief in myself and my students would enable me to meet any challenge.

Naturally, due to my previous lack of professionalism, I had to start at the very beginning. I began by assiduously studying technical orders, manuals, regulations and directives. I eagerly developed helpful methods of reasoning and developed practical applications that would enhance all my presentations. One of my most valuable learning tools in the development of my first group of students was the quest for knowledge and understanding displayed by the students themselves. To satiate and not suppress this quest was a great personal challenge as well as an invaluable learning experience for me. But I did see another quality that was prevalent among the young students. It was the same frustrating reminder of the previous approach to my own career—the "contagion" was rearing its ugly head again. It was the quality of relaxing, taking the easy way out, assuming and reacting without thought. Fortunately, experience was on my side and I was able to combat this menace when confronted with it. I just simply but strongly urged "less assumptions and more crosschecks, less relaxation and more professionalism, less embarrassment and more pride."

I can honestly say that I was very comfortable in my role as a professional crewmember at Castle, and I thoroughly enjoyed helping others attain comfort in their positions. The fruitful rewards of professionalism far outnumbered the additional efforts needed to achieve it. I'm not truly a full-fledged professional yet, but I hope that my attempts at learning to be one are professional. I have definitely learned one valuable lesson that I'll never forget. You cannot "relax and enjoy it." To enjoy your job, you must have pride in your job—to enjoy yourself, you must have pride in yourself. "Professional Results in Daily Efforts"—how astute was the creator of this apt slogan.

As I previously stated, a contagion is the direct or indirect spreading of a disease or evil. The contagion of which I have been speaking is easily communicable by example and manifests itself as a pure lack of a professional approach to personal efforts. But professionalism can also be contagious and can be the very antidote we need to make our jobs more comfortable, rewarding and meaningful. You as an Air Force officer and navigator have the option of taking either route you want. Have you taken the time lately to take a good look at which direction you're heading?

"High Flight"

Oh, I have slipped the surly bonds of earth
And danced the skies on laughter-silvered wings;
Sunward I've climbed, and joined the tumbling mirth
Of sun-split clouds—and done a hundred things
You have not dreamed of—wheeled and soared and swung
High in the sunlit silence. Hov'ring there,
I've chased the shouting, wind along, and flung
My eager craft through footless halls of air.

Up, up the long, delirious, burning blue
I've topped the windswept heights with easy grace
Where never lark, or even eagle flew.
And, while with silent, lifting mind I've trod
The high untrespassed sanctity of space,
Put out my hand, and touched the face of God.

John Gillespie MAGEE, Jr.

A Historical View of "High Flight"

How it Came to Be

"High Flight" is the inspired sonnet of a youthful American flyer who lost his life serving with a Royal Canadian Air Force squadron during the Battle of Britain.

Magee was only 19 years old when his imagination captured all the exultant wonderment of flight with a minimum of words as he piloted his Spitfire along *the windswept heights* above the United Kingdom. In September 1941, just a few weeks after his RCAF unit arrived in England, he dashed off a boyish note to his parents that told how the soaring lines were born: "I am enclosing a verse I wrote the other day. It started at 30,000 feet and was finished soon after I landed. I thought it might interest you."

The letter went to a distinguished address, historic St. John's Church on Lafayette Square, opposite the White House in Washington, DC. The pilot's father, Rev. John Gillespie Magee, was then Rector at this widely known "Church of the Presidents" where the nation's leaders have worshipped since 1861.

Pilot Officer Magee was born in China, where his father had been a missionary since 1912. The boy first came to the United States in his early teens to attend prep school in Connecticut, where his marked literary talent began to show itself. A few years later, he went to England's famed Rugby School, winning the coveted Rugby poetry prize in 1939, a few months before World War II exploded.

Returning to the States, young Magee decided against accepting a scholarship at Yale and instead joined the RCAF because he felt his duty lay in serving the cause of freedom. He was 18 when he enlisted in September, 1940.

The Library of Congress acclaimed "High Flight," ranking Magee "with our best known poets of faith and freedom" and noted literary authorities hailed the sonnet as the work of gallant genius. The plaudits never reached the poet's ears. Within three months of the poem's creation, Magee flew his last mission and, as he prophetically wrote, put out his trusting hand *and touched the face of God,* which he knew all along waited in the sky where he found it.

The original of "High Flight" is preserved as a rare manuscript in the Library of Congress. A copy hangs on the wall inside the entrance to St. John's Church, where its eloquent lines are read by countless tourists and other visitors who come to Washington.

Editor's Note: Reprinted from the October 1973 issue of the WINDICATOR.

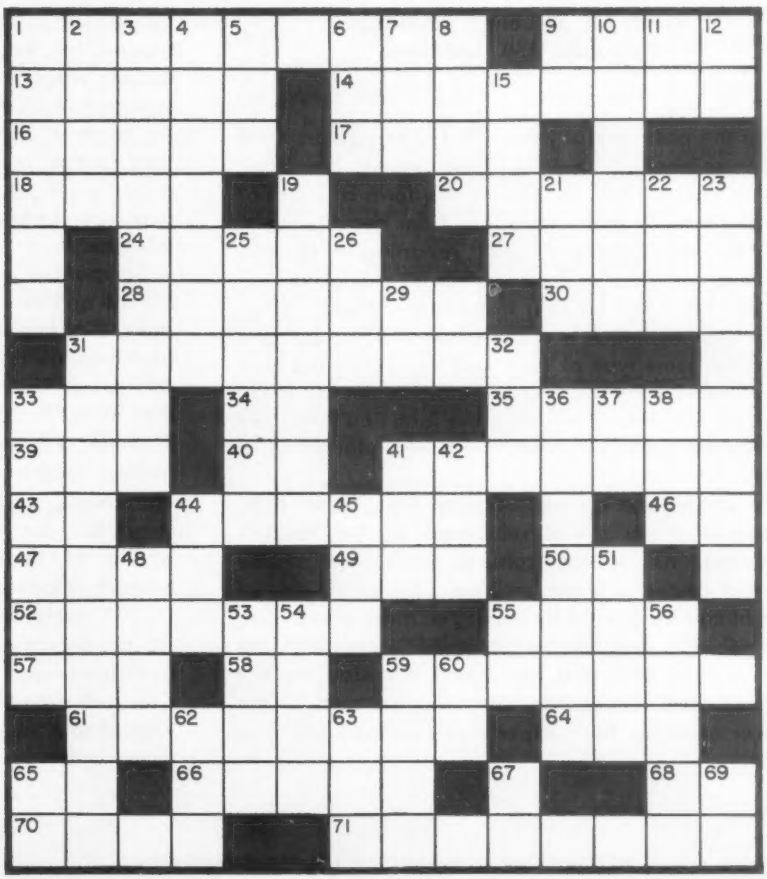
Navwords

ACROSS

1 Grid variation
9 Native of Arabia
13 . . . of Position
14 Guide rope on raft
16 Training program for young officers
17 Lying place or den
18 Was observed
20 Light amplifications by stimulated emission of radiation
24 Unyielding, stiff
27 Kentucky has famous one
28 Type of temperature
30 Short for association
31 Earth's atmosphere and space outside it
33 Equal time point
34 Type of security investigation
35 Air reporting position
39 Zulu time
40 Aerodrome officer
41 Controlled flying lanes
43 Royal observatory
44 Alloy used in making magnets
46 East Indian
47 Laborer or slave
49 Our number base
50 Famous play
52 AC-130 gunship
55 Iranian money
57 Sidereal hour angle
58 Greeting
59 Altitude . . .
61 Short-lived, for the day
64 Actor's equity association
65 Introduces second of two choices
66 Radio fixing aid
68 Veteran's administration
70 To pile up
71 Corrected height shot is Height . . .

DOWN

1 Smooth, transparent
2 Apparent motion of sun
3 Difference between Hc and Ho
4 Scale for reading instrument
5 King of Judah
6 International date line
7 Mouths
8 Call sign of SEA FAC
9 Man's nickname
10 Part of your parachute
11 Article
12 To exist
15 Short for graduate
19 To fly and fight is our . . .
21 Former battleground
22 Radar bomb scoring site
23 Weather summary
25 World
26 Drop suddenly before climbing
29 United Artists
31 Air surrounding the earth
32 Hearing organ
33 Escape from aircraft
36 Pacific island battle site
37 Ancient Egyptian Sun God
38 Sight organ
41 Ritchie was one
42 Electrically charged atom
44 Atomic Energy Commission
45 Noun-forming suffix
48 Tide associated with moon
51 Former Yankee slugger
53 Those guys
54 Type of icing
55 In chemistry, radium
56 Depart
59 Turn into wind
60 Exclamation
62 What Loran signal can do
63 The self
65 Exclamation of surprise
67 All of us
69 Advertisement



NAVWORDS answers on page 28.

THE KC-135: A New Aid for New Roles

1st Lt Earl D. BURT, Jr.
913th Air Refueling Squadron
Barksdale AFB, Louisiana

For the past several years, KC-135 navigators have been consistently getting their names in print. Unfortunately it has not been in the form of kudos or commendations but in messages from Headquarters, Strategic Air Command (SAC) reporting navigation incidents or violations committed by navigators on tankers deployed on long transoceanic flights. It has become evident that, in order to halt all of this adverse publicity, some type of improved navigation aid must be provided for deploying KC-135s. The solution to the problem has been provided in the form of a Palletized Inertial Navigation System, commonly referred to as PINS.

To understand the need for the PINS on KC-135s, one must study the development of the tanker's overwater navigation problems and some of the related causes of these problems. A high degree of insight can be gained by looking at three areas: first, the KC-135's original mission in SAC; secondly, the navigational aids and equipment provided for this mission; and thirdly, the new, diverse roles of the tanker resulting from experiences in Southeast Asia (SEA).

The KC-135 Stratotanker was originally purchased from Boeing by SAC to provide inflight refueling support for intercontinental bombers in a general, nuclear war environment. From its entry into the SAC inventory in 1957, until large scale involvement by the Air Force in SEA in the early 1960s, the tanker was used almost exclusively for strategic ground alert mated with the B-52 Stratofortress. The overwater deployment phase had hardly been thought of up to this time.

Compatible with its general wartime mission, the KC-135 and its navigator were provided only with the basic aids required to navigate to a geographically prominent air refueling point (ARCP). Here they would rendezvous with a bomber receiver, transfer fuel, and then navigate back to a post-refueling base. Included in these aids were ground search radar, Doppler radar, radar altimeter, celestial observation instruments, and the ASN-6/7 dead reckoning (DR) computer. For typical overland missions, this is a wealth of navigational aids, but for overwater missions, it leaves much to be desired and presents the KC-135 navigator with some real handicaps. First of all, the search radar was useless except for weather avoidance—you need radar targets to take radar fixes and except for very few areas, that big ocean is void of any targets. Secondly, Doppler radar returns were not always accurate due to inherent equipment

limitations overwater, and many times the unit remained in memory mode with no useable data at all. And thirdly, since the DR computer was linked to the Doppler radar for groundspeed and drift values, it was of limited use overwater. Considering these problems, the tanker navigator was left with one fairly dependable aid, celestial observations. On long overwater legs, he had to depend on celestial lines of position and pressure LOPs to update or verify his DR positions. This was great as long as it was dark and three-star fixing was available. But, in periods of twilight or overcast, or at times when PLOPs were not available due to SCR 718/APN 133 radio altimeter limitations / malfunctions, and in cases of malfunctioning sextant, the tanker navigator was up the proverbial DR creek without a paddle.

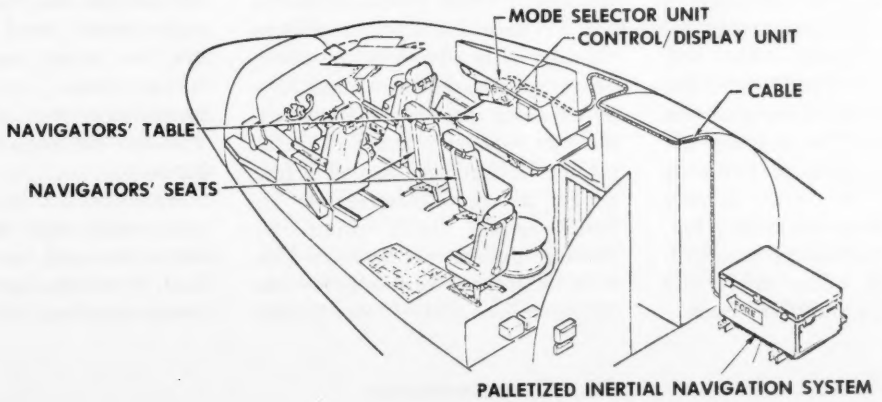
With the increased participation of the Air Force in SEA, SAC and its KC-135s acquired a new mission profile. Tankers were tasked to carry out a variety of non-strategic missions. Among these new roles for the KC-135 were tactical fighter refueling, transoceanic fighter deployments, personnel and logistical transport, emergency air refueling (EAR) , ground alert, and other tactical missions. Obviously, the tanker navigator now had to assume tasks not traditionally required of SAC crewmembers. He now had to plan and fly transoceanic flights with multiple penetrations of ICAO airspace. The tanker navigator was faced with the problem of precision overwater navigation in a tactical situation with a navigation system designed for a general wartime environment void of any ground based radar or radio aids to navigation. The result was an increase in the number of airspace violations and deviations, due, for the most part, to the very limited navigational system on the KC-135 and not to the individual crewmember's abilities.

Staff navigation officers at SAC realized that the KC-135 had become an integral part of not only strategic warfare, but also limited, tactical warfare. To aid the tanker navigator in accomplishing his new duties, SAC set about to acquire an updated navigational aid for a minimum per plane cost. The result of SAC's investigation was the procurement of the Carousel IV Palletized Inertial Navigation System produced by DELCO Electronics.

The Carousel IV PINS is a solid state inertial navigation system composed of the operating control panel in the cockpit and the basic unit located on a pallet in the cargo compartment (see cutaway for layout). Like all inertial navigation systems, the Carousel IV basic unit is composed of three mutually perpendicular accelerometers, a gyro-stabilized platform, and a computer for integrating heading, airspeed, drift, and groundspeed data into a digital readout of a present position in latitude and longitude.

To lower the per plane cost of the PINS, the systems are installed only on tankers deploying or redeploying on transoceanic flights since the basic tanker navigational aids are sufficient for overland missions. At the present time, the PINS are installed on most KC-135s deploying across the Atlantic and Pacific to tanker task force bases or on special missions. The primary coast-out installation bases are Pease AFB, New Hampshire, and March AFB, California, where the tanker aircraft must stop enroute to the overseas deployment bases. At the installation base a short course is conducted to familiarize the navigator with the programming, operation and trouble shooting of the Carousel IV. Upon return from an overseas mission, the aircraft lands at the coast-in installation base for removal of the PINS which then becomes available for other tanker aircraft deploying overwater.

The KC-135 navigator and his crew have been provided with a dependable navigational aid that enables them to accomplish the new roles that came about from Air Force experiences during and since SEA. The Carousel IV PINS will enable the tanker navigator to fly long transoceanic flights during all hours of the day or night with minimal course, groundspeed, and position errors. The PINS provides the tanker navigator with a modern, accurate aid with which to cross reference his celestial data for more professional, effective DR navigation.



Editor's Note: In September, 1974, Lt Col George Lozovoy, a past editor of this magazine, asked me if I was familiar with the article about Nathaniel Bowditch, a marine navigator who was the father of celestial navigation as we know it today. In my ignorance, I admitted that I was not and, in fact, had never heard of the man Nathaniel Bowditch. But my curiosity was aroused, so I immediately dug into our historical files and read the article. I was overwhelmed! Nathaniel Bowditch was indeed a genius who has probably contributed more than any other man in history to the art and science of celestial navigation. His contributions are definitely worth publicizing amongst people who are interested in celestial navigation, so we at THE NAVIGATOR offer this article to you with hopes that you'll enjoy it as much as we did. Our deepest thanks to Col Lozovoy for his interest in the works of Nathaniel Bowditch and to American Heritage magazine for allowing us to reprint this outstanding article.

As an added note, the United States will commemorate its Bicentennial from 1 March 1975 to 31 December 1976, and one of the basic themes is Heritage '76. The Air Force is expected to participate in every way it can so we feel that publicizing the history of a great American navigator is apropos for this eventful occasion.

Nathaniel Bowditch—

THE PRACTICAL NAVIGATOR

Paul E. RINK

Three items were often listed as essential in the seabag of every youngster who heeded the call of blue-water ships and wandered down the long road to the nearest port: a knowledge of the Gospel, a pair of woolen socks knitted by his mother, and a book— *The New American Practical Navigator*. The ascending order of importance was never questioned. The Gospel might in time of peril provide confusing answers, and the socks develop holes, but the book would never fail. It would lead him anywhere on earth and bring him home safely and surely across the trackless ocean.

This was not always so.

Around the end of the eighteenth century, something like an uneasy truce existed between the townspeople of Salem, Massachusetts, and an irascible young man named Nathaniel Bowditch. He had a way with figures the like of which nobody in Salem had ever seen, and if he had stuck to his sums in the ship chandlery where he worked, he and Salem might have gotten along quite nicely. Bowditch, however, was not a man to hide his talents. He was eager, almost before anyone asked, to demonstrate his mathematical skill—often by proving how he had discovered an error in Sir Isaac Newton's *Principia Mathematica*—and if the listener couldn't follow the calculus, he was likely to be called a stupid dolt. This attitude made Bowditch few friends, but it wasn't until he set himself squarely against the maritime dogma of the times and challenged the authority of practical men that he stirred up real opposition. But he also proved that he had the finest mathematical mind in America, if not the entire world. What he bequeathed to succeeding generations—his *New American Practical Navigator*—is proof of his genius.

Bowditch insisted that mathematics does not lie. He said that if two and two made four on land, it was equally true on a ship a thousand miles at sea. He committed

the heresy of proclaiming that mariners should navigate their ships *precisely* by mathematics and celestial observation instead of trusting to practical experience and luck. If they would only put their faith in the unvarying stars, so this land-bound bookkeeper said, ships would reach their destinations more swiftly and safely.

The problem of determining exactly a position on the surface of the globe was one that had long baffled seafaring men. There was nothing new in Bowditch's idea of celestial navigation. Steering by the stars had been practiced for countless centuries, but there was a vast difference between this and using them to calculate a precise position. By the late 1700's, rough instruments and calculations had been worked out for finding one's position on land, but it was a lengthy and laborious process, requiring a great deal of astronomy and mathematics as well as a means of knowing the exact time. Furthermore, the final results were not truly accurate.

In navigating a ship, certain things were possible, of course. Distances run could be determined by dead-reckoning—that is, by measuring the miles traveled through the water and then applying this figure to known compass headings. In beating into the wind, however, where the vessel sideslipped through the water, or in sailing through unknown currents and tides, dead reckoning was liable to grave errors.

A ship's latitude could be determined by celestial observations if the mariner was up on his mathematics and had good instruments on board. Taking altitudes on the sun and moon, and sometimes on such stars as Polaris, Sirius, or Vega, had enabled generations of pre-nineteenth century sailors to establish distances north or south of the equator.

Navigation in those days was actually a pretty rough and ready business. Such refinements as were known for establishing "fixes" were far too complicated for the rugged seamen who walked the poop decks of merchant and navy ships of the period. Captains took their vessels out and—if they were lucky—brought them home by "seaman's eye" and "seaman's feel": the smell and feel of the wind, the look of the sky, the color of the water, the characteristics of the ocean floor far beneath them. Experienced navigators could take sights on the sun and moon and, by following the selected latitude across the ocean, make a reasonably accurate landfall. Bad weather or contrary winds could complicate the navigator's task, however, and he still had no reliable method for determining a position in longitude—his distance east or west of the prime meridian at Greenwich, England.

By 1800, the need for more accurate navigation had become acute. The navies of the world were dividing the earth into far-reaching political and commercial empires; demands for raw materials were soaring; industry was producing surplus goods that commanded enormous profits abroad. Shipbuilders were turning out larger vessels capable of safely carrying heavier and more valuable cargoes. Time was money and power—fortunes awaited the ships that got there first with the most.

Everything was ready and waiting, except that men still did not know how to navigate properly. Voyages that should have been accomplished in weeks took months, and those that should have been completed in months sometimes took years.

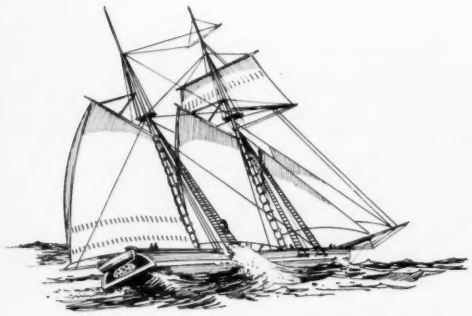
In the face of this need, mariners still held to the old ways of doing things. They took the ships out on seamanship alone. Book learning and mathematics were simply not to be trusted. Many an "arithmetic sailor" in hopes of a quick passage had put his faith in paper and pencil instead of his own good sea-sense and had come to grief. Little wonder that people derided Bowditch and his talk of the infallibility of numbers.

Nathaniel Bowditch began life respectably enough. He was born in Salem in 1773, into a family whose men followed the two professions of so many New Englanders—farming and seafaring. By the time little Nat arrived, the luck of the family seemed to have run out. His mother, Mary Bowditch, was dying, and the child knew more of cold and hunger than anything else.

During the long periods that his father, Habakkuk Bowditch, spent at sea, the boy did what he could to nurse his mother, and to keep her and his small brothers and sisters from freezing to death in the Massachusetts winters. Between voyages, when the unlucky and ineffectual father was home, things were better. Unfortunately these periods always ended too soon, owing to Habakkuk's habit of seeking the solace of rum to help him forget the "awfule Sights he Hadde seen at sea". When the binges were over, Habakkuk took ship again, leaving his nearly penniless family behind to shift as best it could.

Mary Bowditch died one bitter, snowy night when Nat was ten. He was apprenticed to a ship chandler—indentured until he reached twenty-one years of age—and his brothers and sisters were distributed among various relations and neighbors. Though the Bowditch men were noted for brawn, this lonely little boy simply did not grow. He remained weak, short, and spindly—and he stayed that way throughout his life. But his mental capacity made up for what he lacked in physical prowess. His temperament seems to have been choleric, but his mind was clear and, in argument, deadly as a trap. He was phenomenally impatient with his brawnier but less gifted contemporaries if he found them guilty of illogic or overstatement.

Bowditch's first love and passion was mathematics, and his skill



became apparent at a very early age. When he was fourteen somebody gave him an algebra text, and he stayed up night after night with it, completely enthralled by the beauty of its unassailable logic. Books of all kinds were available, even in the Salem of those days, and for the most part they were of a very high caliber. For example, the entire library of the great Irish philosopher and scientist, Richard Kirwan, had been captured off the coast of England and brought home to nearby Beverly by a privateer. There were books in French, Latin, and Spanish, and Bowditch devoured them all, mastering each language that stood between him and the information he coveted. By 1796, when Bowditch was twenty-three, he possessed one of the most thoroughly educated minds in America.

But what was he to do in Salem, and what was Salem to do with him? One small commission came his way. The Commonwealth of Massachusetts hired him to survey his home town. This he did with great dispatch and accuracy; we read that those who were associated with him in the project admitted he was "powerful in calculation".

Once this surveying job was finished, however, Salem seemed to hold little promise for the budding young mathematician and astronomer. Bowditch continued to work in the chandlery. At one end of the long counter he set up a kind of workshop with models of spheres, the heavens, triangles, and other tools of his "useless" profession. When he was not keeping books or arguing with the ship captains who came to buy everything from marling needles to anchor chain, he figured and calculated endlessly.

In the Salem of those days glory, romance, money, and security all came from the sea. Youngsters who could, manned the ships. Those with the knack of command and a quick Yankee eye for profits rose to be captains, often in their teens, and made fortunes for themselves and their owners. The weaklings, like Bowditch, stayed home and did the chores. They kept the books, made out the endless manifests, calculated the profits and losses.

To compound the hopelessness of his position and to make his misery even more acute, Bowditch had fallen in love—with a Salem girl named Elizabeth Boardman, the daughter of a shipmaster who had been lost at sea. She not only returned his love but seems also to have understood him completely. She believed in him and stood up for him and his "nonsense" in the face of the entire seafaring community. Unfortunately, then as now, marriage required money, and Nat could scarcely support himself. The sea—the only source of income that he knew of—was denied him.

At this bleak moment there appeared an old boyhood friend, Captain Henry Prince. Slightly older than Bowditch, he had gone to sea at an early age and had been a shipmaster for many years. Prince seems to have been a very good friend, and what was more important, was inclined to believe in the possibility of accurate navigation by the stars. He had sense enough to know that if what Bowditch said was true, then passages could be accomplished in half or one-third the usual time, with a corresponding increase in profits. Known as one of Salem's shrewdest, most daring and capable captains, Prince was already moderately wealthy, had his eye on a fine white house in Salem, and looked forward to retirement.

He had just been given command of the *Henry*, owned by Elias Hasket Derby, who engaged Prince to take her on a coffee trading voyage to the isle of Bourbon (now Reunion), in the Indian Ocean. Bowditch persuaded Prince to sign him as second mate and clerk and also to let him take along a few pairs of shoes for profitable trade on his own account—an "adventure" it was called in those days.

There probably has never been a more maladroit seaman than the clerk of the *Henry*. To cap his lack of experience and natural ineptitude, he was also inclined to seasickness, a blow to his dignity. He knew that few captains, even old friends, could afford a hand who did nothing but keep books, and pride drove him very hard. It is recorded that he finally became a sort of "assistant" to the helmsman!

There was, however, one consolation: Prince encouraged Bowditch to experiment as much as he liked with pencil and slate. We can imagine the excitement and joy he must have had at this opportunity to verify his theories. Near shore or in dangerous waters, the *Henry* no doubt was navigated by the usual methods, for in spite of Prince's desire to know if there really was anything to this business of mathematical navigation, he was too fine a seaman to take undue risks with his ship. But in the long reaches of the open sea, Bowditch had his chance. As far as he was concerned, the trip was a complete success, and Prince could not help but agree. The *Henry* made a phenomenally fast voyage and the reason was apparent: she had been sailed across the ocean *in a straight line.*

In Bowditch's struggle to perfect his methods, the big obstacle was the determination of longitude when out of sight of land. This, in somewhat oversimplified terms, is arrived at today by calculations relying on the difference between the observed local time at the ship's meridian and the known time at the same moment at the prime meridian in Greenwich. By expressing these degrees of arc, or time difference, in nautical miles,

the ship's exact position east or west of the prime meridian is established.

For centuries, accurate determination of a position in longitude was so vital that many maritime countries, starting with Spain in 1598 and including Portugal, Venice, France, and England, offered very substantial rewards for a solution.

It seems simple enough. You build a good watch, set it to Greenwich time when you leave port, and thus carry the time of the prime meridian with you wherever you go. The trouble was that none of the clocks or watches available in Bowditch's day could come anywhere near the accuracy demanded; in a tossing ship at sea they could not be depended upon at all.

Great Britain had long since established a permanent Board of Longitude to examine all solutions advanced, and for decades had offered the sum of £20,000—an astounding reward for those days—to the man who could invent a reliable clock. It finally went, in 1773, to Joseph Harrison, *before* Bowditch. But it wasn't very practical for many years to come.

Work continued toward developing a practical and dependable chronometer, but meanwhile eminent astronomers and experimenters devoted much effort to finding a way of telling Greenwich time at sea independent of mechanical timepieces. These ranged all the way from the outright use of black magic to improbable schemes involving the orbits of the satellites of Jupiter, or the occultation by the earth's moon of certain stars. None of them worked.

Bowditch, however, turned the trick on the voyage of the *Henry*. The high point for him is very simply recorded in his journal: "...Thursday thought of a method of making a lunar observation." And indeed he had. By means of three simultaneous observations on the moon and a fixed star (or the sun) he was able to calculate the angular distance between them and from this look up the Greenwich time in the *Nautical Almanac*, a work published annually by the Commissioners of Longitude in London.

Bowditch himself modestly writes in the preface to the first edition of the *New American Practical Navigator:* "A new method of working a Lunar Observation is given in this work...it was invented by the author...and taught by him to a number of persons in 1796...he not having seen any method possessing the peculiar advantages of uniformity in applying the corrections..." It was a major achievement. For the first time in history men could accurately establish positions east or west of the prime meridian.*

The *Henry* returned to Salem on January 11, 1796, exactly one year after she had sailed. Bowditch was to have three months ashore.

At this period, the start of the nineteenth century, Salem was engaged in a deadly struggle with Boston to become the queen city of American shipping. The Far East—the Philippines, the Indies, the whole vast Orient—was the prize, richer than any man's imagination could conceive. Daily the ships sailed down the channel from Salem harbor, reaching farther and farther, to return one, sometimes two, sometimes three years later, deeply laden and fat with profits that in a single voyage might run as high as seven hundred per cent. The little New England town was rich in spices, silks, rare goods from the whole world. It rang at night to the boisterous shouts of celebrating seamen. The great shipowners—Elias Derby, the Crowninshield family, and others—exercised a feudal lordship over the whole village and its people.

Old Elias Derby—the same who owned the *Henry*— conceived a bold plan. The route of the Boston ships to the Orient was south to Cape Horn, then north and west across the Pacific. Salem ships took to the east across the Atlantic, doubled the Cape of Good Hope, and then headed north and east again into the Indies. Derby decided that he would send a ship where no ship from Salem following this route had ever gone before—clear to Manila, the fabled pearl, the trading post of the whole Orient.

He owned a big vessel called the *Astrea*—too large and slow for the normal trade routes, but perhaps just the thing for the long and difficult voyage to the Philippines. Derby poured money into her outfitting. Unusually heavy and lofty masts, stout rigging, spars, sails—everything was added to make the *Astrea* fit for the dangerous trip.

As captain, Derby selected Henry Prince, possibly because of the very fast and profitable voyage Prince had just turned in on the *Henry*. In any case, Derby knew that in Prince he had an exceptionally fine seaman who could be trusted to drive a ship to the very limits of her capacity and at the same time keep a sharp eye on those all-important profits.

Now, no matter what explanation Derby or anyone else might have had for the *Henry's* fast voyage, Prince knew that she had been *navigated*. Accordingly, he convinced Derby that Bowditch should go along on the trip to Manila, and the little mathematician was signed as supercargo. The *Astrea* cleared Salem on a stormy day in March, 1796.

The first leg of the voyage took them to Lisbon for water and a cargo of wine, then south for the long reach to the tip of Africa, then north to the isle of Bourbon, a last

**In passing it should be mentioned that around 1800 a reliable ship's chronometer was finally developed. It was a fantastically expensive and complicated mechanism, however, and many years were to pass before it came into general use at sea. The determination of longitude by lunar sights is no longer used, as modern chronometers and more advanced concepts do the job better, but at the time Bowditch's discovery was of enormous importance.*

water stop for Salem ships outbound to the Indies.

With the aid of a favorable monsoon—and Bowditch's navigation, no doubt—the ship worked her way across the Indian Ocean, through the islands, into the China Sea, and thence to Manila. By the time she had disposed of her cargo and reloaded, the monsoon wind, which shifts direction twice yearly, had changed, and was now blowing from the north. With this fair wind behind her, the *Astrea* cleared Manila for Salem again and after an uneventful trip arrived safely in May, 1797, having been gone about fourteen months.

During his first voyage of the *Astrea* to Manila, Bowditch found time to improve and simplify his method of determining longitude until he was fully satisfied that it was reliable. The problem of these lunar sights solved, one further block remained, and it was perhaps the more vexing.

The mathematics of navigation (really applied astronomy)—calculus and spherical trigonometry—were beyond the abilities of most mariners. In addition, they took much too long. If a fix were to be of any practical value to a ship, it would have to be simply and accurately made and it would have to be available soon after the sights had been taken. In spite of his impatience with minds less gifted than his own, Bowditch was fully aware of these problems. How could involved mathematical concepts be made easy?

Attempts had already been made—notably by the famous English mathematician, John Hamilton Moore—to deal with the difficulty by formulating tables for each possible reading of the altitudes above the horizon of the various navigators' stars. This set of figures was then applied to the problem of the moment, and by means of simple formulas, plus plain addition and subtraction, the fix could be made. Once these tables were assembled, the correct solution to any problem in navigation would be available to any seaman, no matter how unlettered, as long as he could read a sextant properly and remember his sums.

In the period after the first voyage of the *Astrea,* Bowditch made the acquaintance of an enterprising young man named Edmund M. Blunt. Blunt was a Newburyport book publisher who had pirated and printed in America a set of Moore's tables, which he called *Moore's Navigator.* Though this book was the best thing available at the time, it was rudimentary, and from it no small part of the sailor's mistrust for mathematical seamanship was derived.

Blunt had heard of Bowditch's genius and begged him to find out what was wrong with the *Navigator.* Bowditch agreed to do what he could. To begin with, he found that Moore's method for establishing longitude was not fully reliable. Secondly, the calculations in the tables had been done so carelessly that the book was literally a mass of errors. We read in Bowditch's journal: "Another error in Moore's...Eight errors in Moore's today...Five more errors in Moore..." And so on. Eventually, Bowditch was to note the incredible total of over eight thousand mistakes. Even to revise these existing tables to the point where they could be trusted, Bowditch needed a great deal of time, another long sea voyage if possible. The opportunity was to come sooner than he anticipated.

Another necessity dictated his return to the sea. During the period ashore he had married Elizabeth Boardman. He continued to work on the Moore revisions, but he quickly found the world does not pay for effort alone. There was only one way of obtaining another financial stake, and so in August of 1798, five months after his marriage, he again sailed with Captain Prince in the *Astrea,* this time for Spain.

Bowditch must have kissed his bride good-by with a heavy heart and deep forebodings. Elizabeth was seriously ill with consumption. In Alicante his worst fears were realized. He received word indirectly that she had died. Bowditch had never been popular in Salem, and a plaintive entry in his journal is indicative of the humble status of this heartsick and lonely man: "...none of my friends in Salem have seen fit to notify me or give me any details of the death of my beloved wife."

The *Astrea* returned to Salem in April, 1799. Bowditch turned his corrections of Moore over to Blunt, and the book was copyrighted in May of the same year. In spite of his lack of personal acceptance in Salem, and in spite of his grief over the death of his wife, there was for Bowditch one ray of light. In certain circles his genius as a mathematician was beginning to be recognized. He was elected to the American Academy of Arts and Sciences. Yet in September of 1799, when his revised edition of *Moore's Navigator* appeared, the title page didn't even mention Bowditch's name.

While the book was on the press—in July—Bowditch again sailed with Captain Prince in the *Astrea,* and again for Manila. Anticipating a third edition of *Moore's,* Blunt had asked Bowditch to continue his corrections, but the day before the *Astrea* left port, Blunt appeared on board with another idea. The moment seemed right, he said, for a whole new book on navigation. Instead of continuing to revise Moore during the voyage that lay ahead, Blunt suggested that Bowditch do a book that would be truly his own—one that would have everything in it that Moore's lacked and that would, above all, be accurate.

Bowditch immediately agreed. He abhorred the blustering, and to him stupid, men who went to sea. Their inefficiency (by his standards), their

heavy-handed intolerance and slavish acceptance of dogma enraged him. On the other hand, he loved the sea deeply and was profoundly moved by the stately grace of the great square-riggers. He was fascinated at the thought of writing a book that could guide them safely about the world by means of careful, accurate mathematics. He was delighted at the idea that something of *his* could enable the great ships to fulfill their inherent functional loveliness and the precise, marvelous logic that had gone into their construction.

Yet Bowditch knew that, except for the vast miscellany of information he had collected in his journals, a book of his own meant starting completely from scratch. It would take years to finish, but as the coast of America dropped astern of the *Astrea,* he summoned up all his enthusiasm and set to work.

Ordinarily, American ships outbound to the Orient waited for the shift in the monsoon and then headed north into the Indies with a fair wind. In steady airs, with the wind from the stern, a ship would not have to tack exceedingly, and positions could be determined accurately enough to give her a reasonable chance for survival in the maze of islands that lay ahead.

Following this procedure —waiting for favorable winds —a vessel might take as long as three years to make the round trip between Salem and Manila. But Prince and Bowditch determined to sail the *Astrea* by the stars alone and have her home in a year or less. Prince was well aware of the chances he was taking; nevertheless, he entrusted the navigation of his ship to the little "arithmetic sailor." When he reached the Indian Ocean, he piled on the canvas and at once headed north into the teeth of the monsoon.

Nowadays it is almost impossible to estimate the very real dangers of such a voyage. During the *Astrea's* first trip to Manila the wind had been dead astern, blowing the ship swiftly and surely to its destination. This time it was dead ahead; tacking back and forth, the ship had to fight her way mile by mile toward Manila.

Such a voyage means long watches when the entire crew was on deck. Time after time the anchor was let fly on the run to save them from a submerged reef or to assist them in clawing off a lee shore. On the ship struggled, through unknown waters, past cannibal islands, relying on charts that were so incomplete and so filled with error as to be nearly useless. And all this in the face of the monsoon—the captain disdaining to wait for the fair wind the Good Lord himself had provided to bring simple and devout mariners safely to their destinations.

For the sailors the worst uncertainty of all, of course, was that of the ship's position, known only to scrawny Nathaniel Bowditch, the supercargo, who could scarcely be trusted to stand a proper watch. Deeper and deeper the *Astrea* worked her way into the tortuous waters of the Indies. Time after time the ship was saved by the superb seamanship of Captain Prince and his crew. Nevertheless, as islands, channels, and capes kept appearing out of the mists exactly when and where Bowditch said they would, even the crew began to be impressed.

Bowditch was not content merely to navigate the ship himself. He knew that if his methods—and the book he was writing—were to be truly useful, they would have to be within the grasp of the most untutored seaman. Accordingly he undertook to teach every man in the *Astrea* to navigate, holding classes and drawing diagrams in chalk on the holystoned decks. The charts were explained to the man. He taught them how to use a sextant. Daily positions were worked out. He refined, sharpened, and clarified his explanations until finally every man aboard, from the cabin boy up, could establish the daily fix. Only then was Bowditch satisfied. He had

already known that celestial navigation was trustworthy—he now knew that the involved astronomical concepts could be made simple enough for anyone to use, quickly and accurately.

In addition to navigating the vessel, teaching the crew, and standing his regular watch, he continued doggedly at work on the book. Besides the tables and the rest of the navigational material, he also began compiling a huge mass of related figures and information. He amended the ship's charts. He developed and put down in precise and simple language methods for taking bearings, calculating distances, speeds, and other data vital to mariners working their vessels close to the land. He formulated exact terms and nomenclature for the construction, outfitting, and handling of ships. In short, he slowly began to compile a bible that would include everything men knew about ships and the sea.

The outward passage was finally completed. The dangerous complex of the Indies was again behind, the run up the China Sea was done, and the final "land-ho!" rang from the masthead. The Philippines loomed dark and low on the horizon, precisely when Bowditch expected them to. Prince swiftly worked his way down the coast and a few days later quite nonchalantly let fly the anchor in the pale green waters of Manila Bay. The *Astrea* had completed the voyage in astounding time: six months, twenty-three days.

Her presence was unbelievable to the people of Manila. The ship claimed the impossible—a run through the Indies against the monsoon—but there was no

disputing the facts as the evidence lay tranquilly swinging on her anchor in the harbor. Soon her crew, and Bowditch in particular, were local sensations—the pride of the handful of Americans living in the city. It was conceded that there was "more knowledge of navigation on board that ship than there ever was on all the vessels that ever floated in Manila Bay". Captain Prince took pleasure in boasting that every man jack could take a lunar sight and work up a position "as well as Sir Isaac Newton himself, were he alive."

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In spite of the fact that this must have been one of the most trying periods of his life, it was not all lonely work. In October of 1800, he married again, this time his cousin, Mary Ingersoll, a strapping, handsome country girl who loved the solitary little mathematician with all her heart. The marriage was extremely happy, and no doubt the affection of this devoted wife helped Bowditch finish the enormous task he had set himself. Mary wanted nothing more than to see that her husband had the chance to finish his book; like poor Elizabeth before her, she had complete faith in him and in what he was trying to do.

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At this time Salem was rapidly becoming the pepper capital of the world. Salem pepper ships bought directly from the natives on East Indian islands, many of them completely unknown, then transshipped tens of thousands of pounds of the precious commodity to markets in Europe and America. The trade was extremely dangerous. More than a few Salem vessels ended their days on some lonely beach or reef, captured by pirates, their crews murdered, eaten, or sold into slavery by the fierce natives. The profits were so fantastic, however, that many were willing to take the risks.

For this trade, a syndicate of Salem merchants purchased a three-masted square-rigger called the *Putnam*—small, but nearly new, fast, and in excellent condition—and selected Nathaniel Bowditch to take her out as master, with a share of the profits. It is not known if Bowditch actually bought into the company, or if his "share" was merely that usually given the captain. In any case, it is interesting to speculate about why he was chosen to command the vessel. Certainly the relatively inexperienced and slight statured mathematician was not the man one might normally expect to find in such a position. The *Putnam* was bound for one of the most dangerous areas in the world. (Only three years later, she was, in fact, lost to the natives and seven of her company were massacred.). She was armed heavily; she was expected to defend herself. If she were to return home safely she would need the most capable and resolute men possible. Perhaps the syndicate desperately needed a fast voyage to catch a certain market, or to meet certain obligations. At any rate, Bowditch commanded the *Putnam* when she cleared Salem for Sumatra in November of 1802.

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The *Putnam* approached the New England coast late in December of 1803, during the height of a terrible storm. For days the whole eastern seaboard had been snowbound by the worst blizzard anyone could remember. A prudent master who found his ship in these waters at such a time kept well offshore, hoping he wouldn't be dismasted or that the seams of his vessel wouldn't open under the pounding of the seas.

There are many tales, most of them no doubt apocryphal, about exactly what happened next. The facts themselves are sufficiently fascinating without embellishment.

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For this trade, a syndicate of Salem merchants purchased a three-masted square-rigger called the *Putnam*—small, but nearly new, fast, and in excellent condition—and selected Nathaniel Bowditch to take her out as master, with a share of the profits. It is not known if Bowditch actually bought into the company, or if his "share" was merely that usually given the captain. In any case, it is interesting to speculate about why he was chosen to command the vessel. Certainly the relatively inexperienced and slight statured mathematician was not the man one might normally expect to find in such a position. The *Putnam* was bound for one of the most dangerous areas in the world. (Only three years later, she was, in fact, lost to the natives and seven of her company were massacred.). She was armed heavily; she was expected to defend herself. If she were to return home safely she would need the most capable and resolute men possible. Perhaps the syndicate desperately needed a fast voyage to catch a certain market, or to meet certain obligations. At any rate, Bowditch commanded the *Putnam* when she cleared Salem for Sumatra in November of 1802.

The ship was lucky. Trading was good, the fast proas of the native head-hunters were eluded, and very quickly she was on her way home with a rich cargo of wild pepper.

The *Putnam* approached the New England coast late in December of 1803, during the height of a terrible storm. For days the whole eastern seaboard had been snowbound by the worst blizzard anyone could remember. A prudent master who found his ship in these waters at such a time kept well offshore, hoping he wouldn't be dismasted or that the seams of his vessel wouldn't open under the pounding of the seas.

There are many tales, most of them no doubt apocryphal, about exactly what happened next. The facts themselves are sufficiently fascinating without embellishment.

Late on Christmas Day, a rumor spread through the murk and gloom that enveloped Salem. It was said that Nathaniel Bowditch had been seen in town! Some claimed it was his ghost. Others said that it was truly Bowditch in the flesh; that he had driven the *Putnam* ashore and had somehow managed to make his way to the village. In any event the news was not good. Ghost or no ghost, if Bowditch was in Salem it could mean only that the ship was lost. The port had of course been tightly closed by the winter blizzard.

The syndicate that owned the *Putnam* must have experienced some horrifying moments before Bowditch finally showed up in dripping oilskins, thin as a rail, and convinced them that he was neither a ghost nor a miserable castaway. The ship? She was tied up safely at Derby wharf!

Bowditch had done the impossible. He had brought the *Putnam* safely to her berth in the midst of the storm. He admitted that two days before, he had had the good fortune to speak another vessel which had helped him establish his position. And on December 24, when the snow had turned to "thick rainy weather, latter part moderate to foggy," he had managed during a lull in the storm to take two good shots of the sun. This definite establishment of the ship's position, plus an excellent compass and a fleeting glimpse of the "Eastern Point of Cape Ann" through the fog as they worked their way up the channel, had been sufficient. Otherwise, all he had done was to apply some "simple arithmetic"!

This was a feat that could not be ignored. Bowditch and his arithmetic had done what no shipmaster in Salem—or anywhere in the world—could have done, bluster as he might. Bowditch was an overnight hero.

From then on his methods were not only put to immediate use but were taught and avidly studied. As the years passed, any man who had sailed with Bowditch proudly considered that he had sat at the feet of the master. Nor was he wrong. For the first time in history, men could venture forth on the ocean and know exactly where they were. To a large extent Bowditch made possible the great age of American shipping. The tall clippers standing out from Canton to New England made their marvelous voyages because they were manned and navigated by men who had studied their *New American Practical Navigator.*

And what has happened to the book over the years? Published continuously since 1802 and now in about its seventieth edition, it has been one of the great best sellers of all time. Bowditch, and after his death his family, carefully amended and republished it until 1868, when the work was taken over by the Hydrographic Office of the Bureau of Navigation, United States Navy. Known familiarly as H.O. No. 9, it is truly a national monument. Until the period after World War I and the advent of newer methods, coupled with the increasing use of various electronic aids spurred on by World War II—Loran, radar, gyrocompasses, inertial guidance systems, to mention a few—"the Bowditch" was the navigator's bible. The book is still going strong as the basic working and reference text on celestial navigation—in the air and on the sea.

Bowditch never again sailed after the voyage of the *Putnam.* As the years passed, he emerged from his shell of loneliness. He took an active, and vociferous, part in community affairs—politics, school elections, and the like; he reared a large and very notable family; he helped establish the first maritime insurance company in America.

In 1823 he moved to Boston with his family, where he continued to prosper. His "commentaries" on Pierre Simon Laplace's *Mecanique Celeste* ran to over four thousand pages, twice the size of the original, and made this notable work by "the Newton of France" available to the English-speaking world. Bowditch bore the publishing expense himself—it cost him $12,000, a third of his life's savings. He also brought out many other works—on comets, meteors, and solar eclipses—but his greatest work remains H.O. No. 9, "the Bowditch".

Honors were heaped upon him. He was made a Fellow of the Royal Society of London and Edinburgh, the Royal Academy of Palermo and Berlin, the Royal Irish Society, the Royal Astronomical Society of London, and many others. He was elected secretary of the East India Marine Society of Salem and offered various chairs in mathematics and natural philosophy— at Harvard, at the University of Virginia, and at West Point. He was elected president of the American Academy of Arts and Sciences. In 1810 he was elected an overseer at Harvard and in 1826 was made a member of its governing corporation. When he died in 1838, ships of all nations in ports throughout the world flew their flags at half-mast as the news spread, and cadets at the United States Naval School wore mourning badges. It was as though mariners everywhere recognized not only the loss of a great scientific and mathematical genius, but of a very good and trustworthy friend, whose work guided them safely across dark and unknown oceans.

But possibly the greatest honor, the one that would have pleased Bowditch most, was the inscription on the commemorative statue erected in Salem by the Marine Society: "...As long as ships shall sail, the needle point to the North, and stars go through their wonted courses in the heavens, the name of Doctor Bowditch will be revered."

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1974 USAF NAVIGATOR TRAINING CONFERENCE

Major Louis A. KUN
323d Flying Training Wing
Mather AFB, California

From 30 October through 1 November 1974, the USAF Navigator Training Conference was held at Mather AFB, California. The conference was hosted by the Air Training Command and was attended by representatives from almost every major command in the Air Force. In all, 21 senior ranking navigators from SAC, TAC, MAC, ADC, ATC, AFMPC, USAFE, PACAF, AAC, AFRES, ANG, and HQ USAF participated in this three day event.

The purpose of this "meeting of the minds" was to "examine the interface between ATC conducted navigator training programs, the major command navigator aircrew training courses and navigator assignment/ utilization policies with the intent of optimizing current and projected training programs." To meet this overall purpose, the conference was divided into four separate but related objectives. These objectives were to:

1. Examine current and projected navigator requirements, inventory, training rates, force characteristics and assignment/ utilization policies.

2. Review undergraduate, graduate and combat crew upgrade navigator training programs.

3. Examine training programs to identify training deficiencies and unnecessary redundancy in the ATC and combat crew training courses.

4. Review and approve the Course Training Standard for UNT Course N-V6A-D, the latest program that incorporates the T-37 and T-43 aircraft and the T-45 simulator.

The conference opened with Brigadier General Robert W. Bazley, commander, 323d Flying Training Wing, introducing the keynote speaker, Major General Oliver W. Lewis, Director of Personnel Programs at Headquarters, USAF. General Lewis' opening remarks made it clear that one of the Air Force's current goals is to cut manpower wherever possible without losing any fighting effectiveness. He stated that fiscal year 1975 strength would be down to about 105,000 officers and 508,000 airmen, the lowest overall force total in many years. General Lewis emphasized that the Air Force would continue to press for optimum training programs and to encourage the Instructional Systems Development approach to insure course content is responsive to validated training requirements. Simulation will continue to be used to the maximum. General Lewis closed his remarks with the observation that the Navigator Training Conference provided an opportunity for the major commands and ATC to air out problems and ultimately help ATC produce better graduates for all gaining commands.

After General Lewis' address, Colonel Robert O. McCartan, 323d Flying Training Wing Deputy Commander for Navigator Training, welcomed the conferees and turned the conference over to Lt Col (Colonel selectee) Francis R. Fanning. Col Fanning, Chief of Navigator Training, Personnel Programs, Flying Training Branch, Headquarters USAF, was the chairman for the conference. His primary job was to keep the conference flowing as per the published agenda and introduce the major command representatives at the appropriate times.

The first day of the conference was devoted primarily to briefings by Air Force Military Personnel Center representatives and dealt mainly with personnel plans and programs. The USAF Personnel Plan and the proposed Rated Distribution and Training Management (RDTM) system were presented and discussed by the conference members. Major Billy Tudor from AFMPC at Randolph stated that the Personnel Plan and RDTM were intended to work hand-in-hand to improve management of the training and manning for Air Force advanced weapons systems. There was also some speculation that the new trend in training would lean towards remaining in the aircraft "world" in which the navigator was initially

trained. In other words, he could plan to remain, throughout his rated career, in one weapon system type. It should be emphasized that this is speculative at this point as nothing concrete has been decided.

Following the briefings by AFMPC personnel, Col Robert O. Mc Cartan discussed some of the personnel needs of the 323d Flying Training Wing. He particularly stressed that MPC should assign young, dynamic officers to Mather's training squadrons. The young lieutenant students can more readily identify with younger instructors with recent experience in an operational unit. The ideal UNT instructor corps should be made up of a diversified and balanced experience base of top-notch officers from the various commands. This would also enhance career salesmanship for the various using commands. The importance of careful screening of potential Mather instructors by the major commands was emphasized.

An issue of high interest to Air Force navigators today, Title 10 of the US Code, was discussed by Col Fanning. He gave a short update of the present status of Title 10 and then threw the floor open to questions and discussion.*

The final discussion item on the agenda for the first day of the conference was a briefing on present Mather programs by Major Bill Wilson, Assistant Deputy Commander for Navigator Training. Major Wilson described the latest syllabus of instruction which includes the T-37 and T-43 aircraft and the T-45 navigation simulator (see article on page 5). After the briefing, all of the conferees were afforded the opportunity to tour the entire Mather training complex and see first-hand the most current innovations in navigation training equipment. Afterwards, a social hour at the Mather Officer's Club wrapped up the first day of the conference.

On the second day, Lt Colonel Claude E. Riggs, from the Directorate of Operations, SAC, and Lt Colonel James Smith, from the 9th Weather Reconnaissance Wing (MAC), gave personnel briefings on their respective commands and each emphasized the areas of present and future navigator manning. After their briefings, the Course Training Standard for UNT was then discussed and proposed minor changes were approved by the conferees. The floor was then open for discussion on anything to do with navigators or navigator training. Some of the areas discussed during this period were the AF Form 21—Navigator's Log, the annual navigator's proficiency exam and ground mission, foreign training, and specialization training within UNT. The second day was concluded with a demonstration of the training capability of the T-43 navigator trainer. All of the participating conferees were duly impressed with the advancements this modern jet trainer affords for teaching basic navigation.

On the third day of the conference, Lt Colonel David C. Broxterman, TAC Directorate of Operations, opened the session and discussed present and future navigator manning within TAC. After his briefing, the conference switched to an open discussion on any new business that conferees wished to bring out. One of the more interesting suggestions was to combine UNT, NBT and EWT into just two separate programs that would ultimately produce either weapons system operators or basic navigators. An action item to study this issue will be included in the conference report.

HQ USAF representatives also agreed to include in the conference report a listing of the current series and types of aircraft and the systems and equipment on each. The list will be used to update training programs as the need arises. Each command will also continue with the evaluations of the UNT graduates. Other action items will be given to the major commands through publication of the minutes.

Overall, the conferees agreed that the conference was highly productive and steps should be taken to insure that it becomes an annual affair. The cross-feed of information was beneficial to all and furthered the ultimate goal of providing the best training possible to meet the Air Force's needs. As it was so aptly and succinctly stated by General Bazley, "We must continue to have a strong basic UNT program that will provide all commands and weapons systems with the very best trained navigator who can progress into any weapons system in minimum time." The 1974 USAF Navigator Training Conference certainly contributed to that end.

EDITOR'S NOTE: Subsequent to the drafting of this article, the Title 10 restriction limiting command of flying units to pilots has been repealed. The bill, as initially passed by the Senate, was favorably considered by the House of Representatives and signed by the President on 18 December 1974.

Guest Cartoonist:
Capt Gregory J. SHEBEST

Hokay Chris--this is a check-Just like any other check!

I'm Paranoid .....Why Aren't You?

Captain Raymond C. WILLCOX
305th Air Refueling Wing
Grissom AFB, Indiana

Although I'm a SAC trained killer and the medics saw fit to verify me humanly reliable, I must admit, with all due modesty, that I do suffer from acute paranoia. Mr. Webster defines paranoia as "a mental disorder characterized by systematized delusions, as of grandeur or, especially, persecution." But how did I ever achieve this state as a rational, educated, well-trained, dedicated, brave, paranoic Air Force navigator?

One day when I was feeling very profound and somewhat worried about my own well-being, I crossed my legs, closed my eyes and, like any guru worth his salt would do, mentally related several seemingly unrelated but well known facts. I concluded that: a. If the good Lord had intended man to fly, he would have provided him with wings; b. All pilots should be required an orientation course in aerial navigation; c. The vast majority of aircraft accidents seem to occur when an air machine is flown adjacent to, if not beneath, the surface of the ground—hence the term airplane and not ground plane; d. And according to the KC-135 Dash-1, it is not considered safe to operate aircraft in close vertical proximity to one another.

In applying these aforementioned well known facts to the well known situation, it becomes obvious that—we do fly without Divine clearance—we are required by regulation to take pilots when we fly—we are near to the ground *at least* twice in the course of a mission—and in the tanker business, we *do* fly in close vertical proximity to other aircraft. So you see, there is a vast, far-reaching conspiracy and THEY are all in on it. And I know it is directed against me....and maybe even YOU.

Climb aboard my padded flight deck and I'll show you how I combat this sinister plot against me. My counter-conspiracy begins right at preflight, and as the pilots do their walk-around, I sneak a look into the 781. While they read the 781, I casually look over the exterior and manage to work something into the conversation like, "Did you watch Johnny Carson last night...What's that puddle of stuff under #4?" I figure that if it's liquid it's supposed to be inside that engine, and if it isn't, I want to know why not!

While we're taxiing out, my 20/20 ears are glued to the radios while the drivers are talking their pilot talk. In my mental map of the aerodrome, I know who is taxiing where because I KNOW those other planes are also part of the Conspiracy. My eyeballs are simultaneously peering out of every window lest they sneak up on me and ruin my whole day. Then just prior to taking the active, I closely look at all the windows. Are they closed tightly and is final clear? What is the flap position and is it the right one for takeoff? Anything I can't see, I ask about—better safe than sorry. Then we're roaring down the runway and my nav goodies are all sliding off the table—also part of the Conspiracy—but I won't be distracted. My eyes dart from engine instruments to overhead electrical panel to runway markers and back again. The pilot rotates and calls for gear up. And quicker than a copilot's speeding hand, I check the vertical velocity indicator and out the window to assure that we are indeed in a positive climb. If not, my shrill, crackling voice screams "ALTITUDE" on call, guard, SAC common, and Quebec upper. Once the worst is over, I casually slip down in my seat to catch my breath and slow down my palpitating heart. But naturally I keep my shell pink ears tuned to the radios lest THEY try to slip something over on me when THEY think my guard is down.

If the navigation leg is next, no sweat. I plan it so that we're at the MEA for Mt. Everest over Kansas. I constantly look for weather. I look for weather in the radar. I look for weather out the window. I look for weather above us and weather below us. I look for weather on the weather flimsy. Weather is a big part of this great Conspiracy. I also manage to navigate a bit while keeping an eye on those three suspicious characters flying with me.

The rendezvous and refueling....another traumatic experience. It is enough to make one believe that those receiver types are also part of the big PLOT. Why won't they talk to me when I call? I just want to relieve my hypertension about their altitude and hot armament. I may have the distinction of being the only SAC navigator to call a breakaway from the 69.5 mile nose-to-nose position. And I may be the only nav to do it twice—the next time one of those Conspirators doesn't give me his altitude and noses in cold. Rendezvous is completed and the first constact sends a shudder through the airframe and through my spine. But since I perfected mind over matter, I no longer have visions of a Buff or Fox Four taking my rudder in its teeth and chewing it all up. I simply tell myself that no one is really back there. But just in case there is, my chute, helmet and oxygen are all hooked up and I'm spring loaded to the "Go" position. In fact, just between you and me, I would bet even money that if the pilot called "Bail Out," by the time he reached for the alarm bell, all he would hear is the sound of rushing air and yours truly would have slipped the surly bonds of that Boeing Flying Gas Station.

Refueling is finally completed and it's time to exit the track. I tell the receiver what we're going to do and I ask him if we are clear. If he says yes, I doublecheck with the Boom to ascertain that we are in fact clear. It's my personal contribution to SAC's two-man policy and my own save thy neck policy.

Now we're on our way home and it is time to regroup for the final onslaught. I closely study the let down book and the enroute supplement and I copy the weather verbatim. Questions flash through my mind as though on magnetic tape and my brain was the computer. Can we land? What are the minimums? What's the emergency safe altitude? Do we need IFR missed approach instructions? How does the forecast return altimeter check with what they gave me? And then the final, painstaking agony begins—we start our descent. I swear I will not let these assassins fly me into the ground. I repeat all altitude clearances and call passing altitudes in ten foot increments, if necessary. I check the altimeter setting for the tenth time and cross check all altitudes with the absolute altimeter. I have also been known to pray a lot. I pray for the gear handle, the flap handle, the speed brakes, the angle of attack indicator, the altimeters and the airspeed meters, and when I've said a prayer for each thing we need for a safe approach and landing, I start all over again just to be sure. Then I spin the landing wind. "Pilot, Nav—your crosswind component is four knots from the left.... where's your wheels?" He *knows* that I can see the gear indicators. That just lets him know that I refuse to fall for that old gear up landing trick. I monitor the approach on the radar and out the window and I watch the altimeter and airspeed meter like a hawk. And those radios—my ears are absolutely geared to them. Tower gives a breakout and the pilots very cooly pretend not to hear. But I tell them! I haven't come all this way just to run over some clown on the active and spoil his whole day.

A single full-stop landing isn't too bad, but Lord how I hate that crash and dash! Transition rhymes with inquisition—only it's nowhere near as holy. It's especially bad with an IP on board since the apprentices can do touch and go landings and all kinds of queer things I don't think the airframe was designed to take. But I watch THEM like a hawk. If THEY raise the gear, I immediately put a banana in my ear. It's quite simple, really. Not only does gear rhyme with ear, but it is no more unnatural to have a banana in one's ear than it is to land with the gear up. Heaven forbid if we ever plow one in with the gear up. The accident board would probably conclude that the largest contributing factor was a banana in the navigator's ear.

Ahh, sweet terra firma—we're finally on the ground! And again it is all ears and eyeballs until we're safely off the flight line and in the comfort and safety of our parking spot. I can finally breath freely and think about that beautiful meal I'm going to have to help me gain back those ten pounds I just lost.

As you can see, it is awfully hard work being a full-fledged, honest- to- goodness paranoid. But it is all worth it! I can already envision that glorious day in the future when my yet unborn grandchildren will come to the Home and ask "What did you do in the war, Grandpa?" And I will say with a crazed gaze and a W.C. Field voice, "Children, your Grandpa passed gas and single-handedly stood off the greatest Conspiracy ever perpetrated upon Air Force navigators. Ah yes, I beat 'em all."

Answers to NAVWORDS puzzle from page 13.

1 G	2 R	3 I	4 V	5 A	6 T	7 I	8 O	9 N		10 A	11 R	12 A B
13 L	I	N	E	S		14 D	R	A	15 G	L	I	N E
16 A	S	T	R	A		17 L	A	I	R		S	
18 S	E	E	N		19 M			20 L	A	21 S	E	22 R 23 S
S		24 R	I	25 G	I	26 D			27 D	E	R	B Y
Y		28 C	E	L	S	I	29 U	S		30 A	S	S N
	31 A	E	R	O	S	P	A	C	32 E			O
33 E	T	P		34 B	I				35 A	36 I	37 R	38 E P
39 G	M	T		40 A	O		41 A	42 I	R	W	A	Y S
43 R	O		44 A	L	N	45 I	C	O		O		46 E I
47 E	S	48 N	E			49 T	E	N		50 J	51 B		S
52 S	P	E	C	53 T	54 R	E			55 R	I	A	56 L
57 S	H	A		58 H	I		59 C	60 H	A	M	B	E R
	61 E	P	62 H	E	M	63 E	R	A		64 A	E	A
65 O	R		66 O	M	E	G	A		67 W			68 V 69 A
70 H	E	A	P			71 O	B	S	E	R	V	E D

POSTGRADUATE NAVIGATOR TRAINING IN THE RAF

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Editor's Note: To quote the Royal Air Staff at the British Embassy in Washington, DC, "this article reflects current policy in the Royal Air Force. It is possible that several changes could occur in the near future in pursuance of the current UK defence review."

Acknowledgement: Article, "The General Duties Aero Systems Course," RAF Magazine, "Air Clues," October 1974.

Within the U.S. Air Force, postgraduate training for navigators tends to be orientated towards a particular role or a particular type of aircraft. Probably the only exception to this within the purely navigational field is the Senior Staff Navigator Course held at Mather AFB, California. The Royal Air Force (RAF), however, provides further general training, in various forms, for many of its experienced navigators. In some areas, this is done because the RAF has different requirements, but in others, though the requirements are similar to those of the USAF, the RAF takes a different approach. It may be of interest to USAF navigators to learn a little about this postgraduate navigation training from an RAF fugitive, at present on exchange service as a UNT Section Commander at Mather. The writer makes no apology for any phrases or spellings which are peculiarly British. On the contrary, he hopes that at least a few of them may survive the typist, the editor, and the printer!

This article will deal with three different courses which the RAF navigator may undertake at some stage of his career. They are the Navigator Refresher Course, Staff Navigation Course and the Aero Systems Course.

All of these courses use the Dominie aircraft, which the RAF also uses in the advanced undergraduate stage of its navigator training. The Dominie is a twin-jet aircraft, similar in size and appearance to the T-39. In its civilian version, as the HS 125, it enjoys a respectable slice of the executive jet business in both Europe and North America. The Dominie has navigator stations for two students and one instructor. Navigation aids fitted are Decca, VOR, ADF, Doppler, Automatic DR Computer, and the inevitable periscopic sextant.

Navigation Refresher Course (NRC)

The purpose of the NRC, as its title implies, is to provide refresher training for navigators who have been away from active navigation for some time. Most of them, of course, will have just completed a ground tour, but other reasons may include a long period on the ground for medical reasons, or perhaps a period out of the Service. The course is sometimes used also as an orientation (and language school!) for USAF navigators starting exchange tours with the RAF.

To explain the need for this course, it is necessary to say a word about the nature of ground tours in the RAF. An RAF flyer is not required to maintain flying proficiency during a ground tour. He is not encouraged to do so, and no facilities are provided to allow him to do so. The view is taken that the officer's ground duties will be more efficiently carried out if he is not frequently absent from his desk flying, or perhaps more often awaiting the vagaries of weather and maintenance in an attempt to fly. Naturally, during a ground tour, he will lose not only his proficiency, but also his familiarity with current flying rules and procedures. Hence the need for the NRC, and for its pilot equivalent.

The NRC is conducted at the RAF navigation school at Finningley, in Yorkshire, and lasts for eight weeks. In effect, the course is itself a miniature navigation school, its syllabus covering the whole field of navigation, both in the classroom and in the air. Each student flies about 40 hours during the course, including an overseas flight, normally to Gibraltar.

Staff Navigation Course (SNC)

The SNC is held at the RAF College, at Cranwell, in Lincolnshire, and its duration is four months. The RAF College has recently been reorganized, so that it now combines functions which

equate to those of the USAF Academy and Air War College. The SNC is administered by the war college department, known officially as the Department of Air Warfare. Navigators selected for the course typically have one to three flying tours behind them, and are normally flight lieutenants (captains), though the occasional squadron leader (major) or flying officer (1st lieutenant) may be included. They are drawn from the complete spectrum of aircraft types and roles within the RAF, and most classes also have one or two navigators from British Commonwealth or foreign countries. The USAF exchange officer at the RAF navigation school normally takes the SNC as a preparation for his post.

The course aims to provide a nucleus of navigators whose knowledge and understanding are deeper and broader than those of the average "shop floor" navigator. From this nucleus can be drawn instructors for the navigation school and the operational conversion units, squadron and station navigation leaders, and junior staff officers in posts where navigational knowledge is necessary. Now, it may not be vital, in every job of this sort, to know the formula for scale deviation on a Lambert Conformal chart, or to understand the second-stage integration terms in an inertial navigation system, but the general depth of navigational knowledge, over a wide field, which the SNC provides, must stand the incumbent of any of these posts in very good stead. His thinking is more soundly based and more valid on a range of subjects, though he may himself remain unaware of the improvement, as it is his own datum which has been raised by the course.

Like the NRC, the SNC covers all navigational subjects, but the SNC, of course, has a deeper theoretical content. As a lead-in to the specifically navigational subjects, the first weeks are spent in bringing the student up to speed in the mathematics and physics he will need. The theme which underlies the 40 hours' flying syllabus is the evaluation of equipment errors and trends during the normal navigating process, and the actions which can be taken to correct or allow for them. There is an overseas flight, and emphasis is also placed on gyro/grid, low level, and night astro work.

Many navigators attending the SNC, of course, are highly qualified and respected in their own specialized fields. Often, though, these "kings" in their own fields have serious problems when confronted with something new, and the mind-opening process necessarily involved in the adjustment to this situation can be a painful one. Most navigators survive the experience, however, and are the better for it. They gain also from a very useful by-product, in the informal exchange of ideas and techniques with fellow course-members from widely differing backgrounds.

Aero Systems Course (ASC)

The ASC, like the SNC, is run by the Department of Air Warfare of the RAF College, at Cranwell. Its duration is 50 weeks, and its purpose is to provide selected flight lieutenants and squadron leaders with an advanced education in modern integrated aero systems. This education prepares them for appointments concerned with: a. Operational Requirements; b. Development and evaluation of delivery, navigation, and weapons systems; c. Policy, training, and operational standards for aero systems; d. Development of operational tactics and techniques.

The ASC evolved from the old Specialist Navigation Course (Spec N), which, in the course of a very long history had produced some illustrious graduates, notable among them being Sir Francis Chichester. As the complexity of aircraft equipments increased, the content of the Spec N course necessarily embraced a wider field than the purely navigational. At the same time, with the increasing cost of aircraft and their instrumentation, and with the development of the aero systems concept, it was becoming increasingly clear that there was a need for aircrew officers—not only navigators—who were highly trained in the aero systems field. These officers were necessary to provide the vital link between the Air Staff, who must retain responsibility for formulating and progressing operational requirements, and the scientists and manufacturers who translate these requirements into hardware. Also, training concepts, tactics, and

operational techniques had to be developed for the use of these complex systems. A modified Spec N course was seen as the vehicle best suited to produce officers who were suitably trained for these tasks.

In 1967, therefore, the difficult decision was taken to end the Spec N course, and 1968 saw the start of the first ASC. Despite the eligibility of pilots and other aircrew for the ASC, about three-fourths of the first class were navigators, and this proportion has remained fairly constant ever since. Each year a USAF navigator attends the course, and the Royal Australian Air Force sends students regularly. New Zealand, German and Italian students have also attended, while the Canadian Forces have their own Aero-Space Systems Course, which is run on similar lines.

The typical ASC student will have completed two or three flying tours. He will have shown above average flying ability, and also a clear potential for high quality performance in the command and staff field. There is no stated academic requirement for entry to the course, but few are chosen who have not demonstrated ability in the field of mathematics, physics, or engineering, to about the equivalent level of a United States bachelor degree. Without this type of background, the ASC student would soon encounter serious problems.

The course begins with a preliminary studies phase, which is designed to provide the basic knowledge needed for the more specific studies which follow. In this phase, a foundation is established in mathematics, statistics, electrical and control theory, computers, aerodynamics, and aircraft performance. Most students need to draw on their own background knowledge in as many of these fields as possible, and to devote many off-duty hours to private study, in order to keep up with the very fast pace which is set.

The applied studies phase of the course covers a broad range of topics. The student examines both the principles and the specifics of a representative sample of current and future inventory equipment, in avionics, guidance, displays, delivery and weapon systems. He also undertakes a course of operational studies, both within the College and on visits to operational units. Further visits are made to manufacturers in the aero-space industry and to military research and development establishments, while visiting lecturers from these fields regularly make their expertise available to the course. Naturally, most of the visits are in the UK, but a tour of the United States adds a most valuable breadth to the range of equipments, ideas and techniques which the ASC student is exposed to.

Concurrently with the applied studies phase, the student receives an extensive phase of training in flight trials techniques. He conducts his own trials of equipment in the Dominie aircraft, performs the relevant statistical analyses, and writes the reports. Further flight trials training is provided by a flight over the North Pole in a Britannia transport aircraft, crammed for the occasion with inertial systems, gyro platforms, long range fixing aids, digital computers, and astro computation devices. Finally, each student writes a major service paper on a current aero systems topic, involving many weeks of research. Much of the work which the course member undertakes in this trials phase goes well beyond the limits of a mere course exercise, and is of real value to the operational and procurement planners.

CONCLUSION

The RAF navigator, then, has the opportunity to improve his professional knowledge at various stages of his career. His natural career progression will probably demand that at some time he needs the renewing influence of the NRC. If he is interested in instructing, or in navigation staff work, he will apply for the SNC. If trials work appeals to him, or research and development, and if he has the necessary background and ability, he may compete for a place on the ASC. Naturally, there are many able navigators who do not have the inclination or the aptitude for the type of work which the SNC or the ASC lead to. For these navigators, highly successful careers are open through the normal progression of operational flying and command and staff training. But the SNC and the ASC can provide another string to the navigator's bow, which at the same time fits him for posts which are vital in the modern role of his Service.

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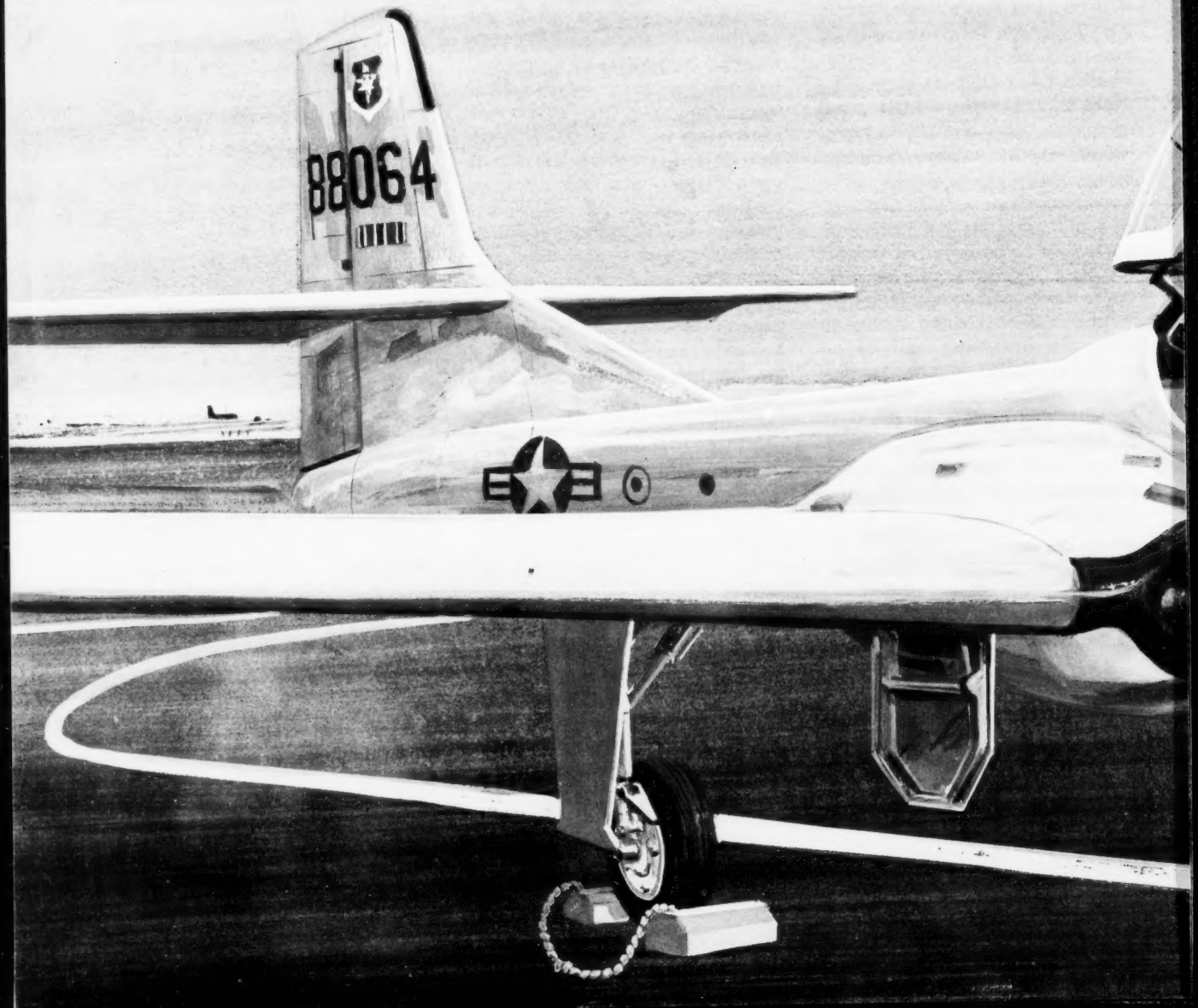
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